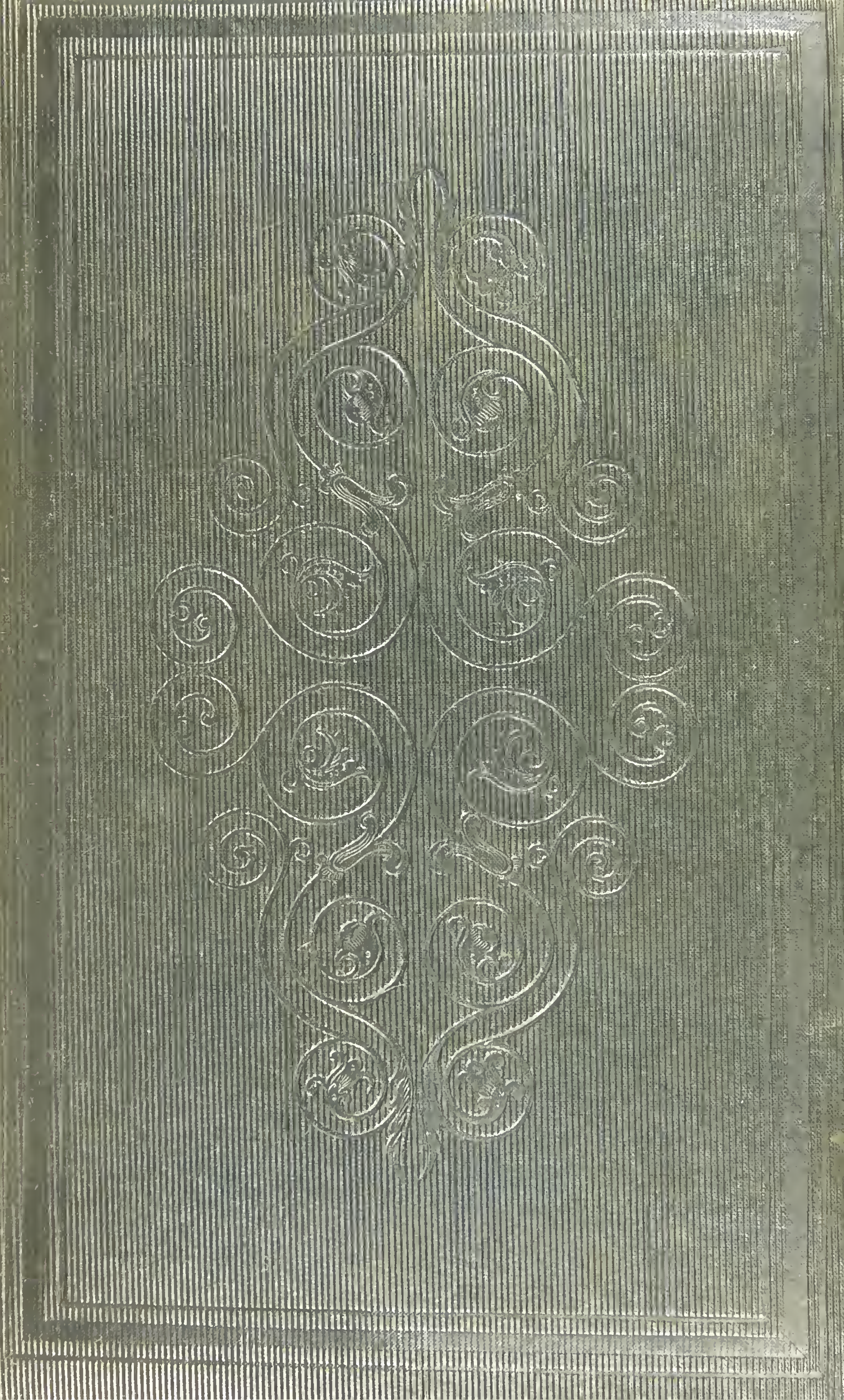

Ci 2.13.

R34-603

With the Author's
Compliments

ON

THE REMOTE CAUSE

OF

EPIDEMIC DISEASES.

ON

THE REMOTE CAUSE

OF

EPIDEMIC DISEASES.

BY JOHN PARKIN,

HONORARY AND CORRESPONDING FELLOW OF THE ROYAL ACADEMIES OF MEDICINE AND
SURGERY, IN MADRID, BARCELONA, AND CADIZ; FELLOW OF THE ROYAL MEDICAL
AND CHIRURGICAL SOCIETY OF LONDON; GRADUATE IN MEDICINE OF THE
UNIVERSITY OF ERLANGEN; ETC., ETC., ETC.

"What this cause is we know not; and we know that no one else understands it. We cannot speculate upon it; we believe it, in short, to be beyond the reach of human knowledge."—*Lancet.*

LONDON:

JOHN HATCHARD & SON, 187, PICCADILLY.

MDCCCXLI.

DRURY, PRINTER,
17, Bridgewater Square, Barbican, London.

TO THE RIGHT HONOURABLE

THE EARL OF CLARENDON, G.C.B.

&c., &c., &c.

My Lord,

In dedicating the present work to your Lordship, I have been influenced by one motive only — a desire to express, on the first proper occasion, the high sense I entertain of the considerate attention, which it was my good fortune to receive from your Lordship, during a professional visit to the capital of Spain. To that support I was principally indebted for the honor of having a ward assigned me by the Spanish Government, in the General Hospital in Madrid, for the prosecution of my inquiries respecting the efficacy of a particular remedy in the fevers of that country — inquiries which, though principally carried on in the province of Valencia, could not have been completed without this advantage.

That, in the midst of such important avocations, as those which then occupied the time and attention of your Lordship,—and in which the welfare of Spain, and the interests of Great Britain were alike involved,—the pursuits of so humble an individual, and on a subject so entirely professional, should have been entered into and promoted, I can only ascribe to the circumstance, that my object was considered by your Lordship to be the advancement of the Medical Art; and, consequently, the welfare of the afflicted in that and other parts of the world—an object at all times sufficient to engage, not only the sympathy, but the best exertions and services of your Lordship.

For these services, my Lord, and, more particularly, for the kindness and urbanity with which they were bestowed, I must ever remain,

Your Lordship's most Grateful,

And obedient Servant,

THE AUTHOR.

18, *Dover-street*,
Piccadilly, *Sept*. 1*st*, 1841.

PREFACE.

In publishing, in a separate form, a treatise, which contains a theory so different from those hitherto proposed, I would wish it to be distinctly understood, that this has not been done from a feeling that the matter is perfect, and the materials complete; or, that the several propositions put forth by me, do not require to be attentively weighed and discussed by others. On the contrary, I feel assured, it is only by discussion that the truth of this, like all other theories, can be ascertained; for it is altogether impossible that any single individual could do more than lay the foundation of such a superstructure, which must require the assistance, not only of a number of individuals, but, of coadjutors in every part of the world. This will be apparent by a perusal of the work itself; for the facts, that would tend to confirm, or refute, the hypothesis now made, must be derived, not from a single locality, but, from various and distant regions, and from nearly every country, with which we are acquainted.

As, however, we live in an epidemic period, and as so few years have elapsed since the first appearance of the Epidemic Cholera, the facts connected with its spread and propagation must be fresh in the recollection of all. I would hope, therefore, that those individuals who, either by accident, or the nature of their pursuits, are acquainted with the occurrence of any of those phenomena which bear on the subject of this work, may be induced to communicate the result of their observations, in order that the truth of the theory, which has now been given, may be confirmed or controverted.

It is also a cause of regret to me, that there is an omission of some dates and other references to particular authorities, which I have been unable to supply. But the truth is, the subject was taken up by me, as a mere matter of amusement, during my convalescence from a long and painful illness; and when I was incapacitated from other and more active duties. Not having the remotest idea *then*, that the notes which were made during the course of my reading, would ever be required, except for my own amusement and satisfaction, I was consequently careless as to the names of authors, and other particulars. After this explanation, however, I shall stand acquitted, I trust, of any intentional neglect of this kind; for it would afford me much pleasure to rectify the omissions, if the opportunity should be afforded me.

ERRATA.

Page 23, *line* 17, *for* "Siberean," *read* "Siberian."

Page 32, *line* 19, *for* "peninsular," *read* "peninsula."

Page 33, *line* 11, *for* "Taulna," *read* "Jaulna."

Page 37, *line* 23, *between* "than" and "the," *insert* "of."

Page 40, *line* 9, *for* "curvilenear," *read* "curvilinear."

Page 40, *line* 24, *for* "eastern," *read* "western."

Page 40, *line* 27, *for* "west, *read* "east."

Page 42, *line* 9, *for* "Arat," *read* "Aral."

Page 43, *line* 25, *for* "Bagota," *read* "Bogota."

Page 53, *line* 15, *for* "different," *read* "opposite."

Page 56, *line* 15, *for* "collection of waters," *read* "collections of water."

Page 119, *line* 17, *for* "towns," *read* "places."

Page 120, *line* 1, *for* "himself," *read* "afterwards."

Page 123, *line* 14, *for* "Corinthia," *read* "Carinthia."

Page 131, *line* 19, *for* "Ahemedabad," *read* "Ahmedabad."

Page 180, *line* 24, *for* "where," *read* "when."

CHAPTER I.

There is, it has been remarked with much truth, no subject connected with the temporal interests and concerns of mankind in which, in the abstract, they are more fearfully engaged than in the study of those diseases which occasionally ravage extensive districts, attacking with indiscriminate fury all persons susceptible of their influence, or exposed to the causes which ensure their propagation. War, however destructive in its sphere—famine, however pinching and disastrous, presses heavily but on the denizens of comparatively small surfaces of the earth. To the one, human conventions may put a period—human industry and the natural and speedy revolution of the seasons afford a certain remedy to the other. But pestilence, commencing in one quarter of the globe, soon spreads over the remainder; while human power has been hitherto unable to arrest its progress, and human skill insufficient to prevent the dire effects which have so invariably followed in its train.*

---

* *History of the Epidemic Cholera.—Lancet*, 1832.

Springing up spontaneously, it attacks, without discrimination, all persons within its reach—the old and the young; the rich and the poor; the strong and the sickly. Having selected its tithe of victims, it marches on to enact the same scenes, and to commit the like devastation in other districts. When, apparently exhausted by these conflicts, it has at length slumbered for a time, and men have congratulated themselves on the disappearance of the destroyer, it suddenly re-appears; and, seeming to have acquired fresh strength by its apparent defeat, commences its attacks with redoubled fury.

Knowing no distinction of country, and being unopposed in its progress by any barrier of art, or the natural boundaries of kingdoms, it numbers among its victims the Asiatic and the European; the negro and the white man; the inhabitant of the old and the settler in the new world. Not confining the sphere of its operation to the land, it traverses, with equal ease, the boundless and the trackless ocean; visiting alike the far distant sea-girt isle, and the solitary wandering bark.

Sad and melancholy as these descriptions are, fortunate would it be, if disease and death were the only evils with which the human race had to contend at such periods. But, as if the above catalogue were not enough, man—weak, ignorant, presumptuous man—has added to the amount by woes and sorrows of his own forging. The affrighted multitude, seeing their fellow-creatures cut off by the agency of a power equally inexplicable and extraordinary and wishing to account for it by their own imperfect knowledge, have referred the cause to the machinations of their fellow-mortals. Hence the persecution of the Jews, at one period, and the massacre of particular persons, or whole bodies of men, at another—individuals who, from accidental circumstances, were at the time the most obnoxious to popular suspicion, prejudice, and hatred.*

Thus, in the black death of the fourteenth century, the Jews were accused by the people of poisoning the wells; and so general was this belief that, in many places, criminal proceedings were instituted against them by the local authorities, who sanctioned alike their conviction and execution. Independent of other towns (for the same tragical events were witnessed over the greater part of Germany), at Strasburg alone, 2,000 Jews were burnt alive; while at Mayence, 18,000 are said to have been put to a cruel death.† Although, fortunately, we have not to record such acts in the nineteenth century, still we are not entirely free from the effects of similar ignorance and prejudice. Thus the physicians in Hungary, the agents of government in France, and the monks in Spain, were accused of poisoning the wells; and, in many instances, murdered by the infuriated and infatuated populace.

---

* "No reasoning," says Dr. Ireland, speaking of the plague of Milan, in 1630, "could persuade the people that they were not suffering from the malignant agency of poisoners: and so strong was the ascendancy of this notion, that not only common friends, but members of the same family, *and even husbands and wives* grew to be suspicious of each other."—*On the Plague of Athens, by the Rev. Dr. Ireland.*

† *Hecker; on the Black Death of the Fourteenth Century.*

Such are the consequences resulting from the ignorance and credulity of the unlearned. Painful it is to reflect, that the evils arising from what it will be my endeavour to show are the false views of the learned and scientific, have also been injurious and hostile to the best interests of humanity. I allude to the promulgation of the doctrine, that *contagion* was the sole and only cause of the extension or propagation of these maladies. From this doctrine have arisen those sanitory regulations, which are productive of so much injury, and such irreparable losses, both to individuals and to communities at large. But these evils are trifling when compared with the separation of the sick from their home and their kindred; and their isolation from all who might administer to their wants, with that sympathy which friends alone can feel or express—for the committal of their persons to hirelings, who, for the sake of gain, are induced to undertake such offices, is, to say the least, an inhuman and unwise measure. To find what the results of the prevalence of such a doctrine are, we have only to turn to the writers of the fourteenth century, one of whom, Boccacio, in detailing the horrors of the black plague of that period, states, "When the evil had become universal, the hearts of all the inhabitants (speaking of Florence) were closed to feelings of pity and humanity. They fled from the sick, and all that belonged to them, hoping by these means to save themselves; others carried their precautions still further, and thought the surest way to escape death was by flight. They therefore left the city, women as well as men, abandoning their dwellings and their relations, and retiring into the country; but of these also many were carried off, most of them alone, and deserted by all the world—they themselves having set the example. Thus it was that one citizen fled from another; a neighbour from his neighbours; a relation from his relations; and, in the end, so completely had terror extinguished every kindlier feeling, that the brother forsook the brother; the sister the sister; the wife her husband: and, at last, even the parent his own offspring, and abandoned them, unvisited and unsoothed, to their fate." But enough of such scenes! It needs not, alas! the pen of fiction, or the sober but more heart-rending reality of truth, to paint the horrors of such woes, in order to inflame the imagination, or to raise the sympathies of any one in the present day, when both have been so powerfully, and so recently, excited by the recurrence of catastrophes, less in degree, it is true, but similar in kind to those now detailed; for although our own country has been mercifully spared, during the visitation of the late epidemic, other countries have suffered severely, both from the ravages of the disease, and the moral and social evils which it brought in its train.*

At no period, then, more appropriately than at the present moment, could we apply ourselves to an investigation respecting the remote cause of these visitations; for to the agitation and dismay produced by the appearance of the epidemic cholera has succeeded a calm, which will enable us to discuss with attention the facts bearing upon this important question; while the remembrance of the past, and the fears for the future, must render the subject alike interesting and important to the generality of persons. Besides, the study of the facts which have necessarily been presented to our notice during the prevalence of the late epidemic, has forced upon us the conviction, that the cause of these visitations—"the precise specific cause of the disease—that," to quote the language of the French academicians, "in virtue of which the epidemic exists, and without which it would not have arisen—remains entirely unknown, in spite of all the hypothetical opinions which have been put forth on the subject."*

---

* It may, perhaps, be thought by some, that, in the present enlightened state of society, such conduct as that before reverted to would not, and could not be witnessed. But if we have been spared the recital of such scenes, it has simply been because the ravages of the epidemic cholera were less; and because, also, there was not the same faith in the doctrine of contagion in the nineteenth, as in the fourteenth century. In England we could hardly imagine what the results of a belief in this doctrine really are; for the fears of the public, which had been excited by the regulations and opinions of the first board of health, were speedily dissipated by the exertions of the press, backed, I am proud to say, by the majority of the profession in this country. That we should otherwise have witnessed the same conduct, and the same scenes as those which took place in the black death, we may be convinced from what occurred in other countries where the contagious nature of the malady was firmly believed in.

Although thus obliged to acknowledge that the theories hitherto broached on this subject are vague and unsatisfactory, it is something, as M. Marin Desbrosses has observed, to discover our ignorance, and to dare to confess it with honesty. He who has optical illusions, adds this writer, will certainly take a false route. The blind man, on the contrary, proceeds circumspectly, and uses precautions which lead him more certainly to his destination.† Let us hope that such will be the case in the present instance; for, having discovered that the path we have hitherto trodden has been the wrong one, we may be induced to seek, and, ultimately, be enabled to find the one that leads to the temple of truth. Entertaining a theory at variance with and different from those hitherto broached, and believing that it explains, not only all the facts bearing on this important subject, but, also, the various anomalies which belong to all other and acknowledged theories, I am induced to come forward on the present occasion, in order to make known my opinions, and to advance a few arguments in support of their truth.

---

* *Report of the Academy of Medicine, in Paris, on the Epidemic Cholera.*

† *Histoire de l'Epidémie du Cholera Morbus, dans le departement de Loir, &c.*

In the first ages of the world — periods when intercourse and communication between different and distant nations were either very limited, or, else, almost entirely unknown—people could have had no other theory in order to account for the production of epidemic diseases than that which they entertained with respect to all other or endemic affections.* Thus, when a plague sprung up in any particular locality, town, or country, and again subsided after a short or certain interval, it must have been inferred, that the cause was the same as that productive of fevers, or other maladies peculiar to the place; and which the inhabitants were accustomed to witness at certain periods of every year. Contagion, or infection, could not then, we may presume, have entered into the minds of men; for as it would be impossible to refer the production of endemic diseases to such an agent—inasmuch as they only appear at particular periods of the year, and in particular situations, notwithstanding that human intercourse and commercial traffic continue the same at all times—so, on the other hand, it was natural for them to ascribe the production of epidemics to the same cause; for they must have been ignorant that the latter had previously affected other portions of the globe; or, that they subsequently extended to different and distant regions. Hence, the aphorism of Hippocrates, that "*Aer est omnium rex morborumque causa*," applied equally, at that period, to epidemic and endemic diseases.

---

* According to Papon, the origin of plague is unknown, being lost in the obscurity of ages. We may therefore conclude, that it is coeval with man himself.—*De la Peste; ou, Epoques Mémorables de ce Fleau.*

But when commercial traffic and social intercourse became more extended and frequent, and the occurrences which took place in one country or town were generally known to the inhabitants of other regions, a different opinion seems gradually to have taken possession of their minds.

Observing that epidemic diseases are characterized by their universality and extent; and by bringing under their influence *not* a few individuals in some single and particular locality, but a large portion of the whole human race, embracing every country and latitude on the surface of the globe; men have invented a theory to account for their origin, different from that entertained for all other maladies. Remarking that a disease, which has sprung up in some particular locality, thence spreads slowly but surely, and as it were step by step, over a large portion of the inhabited part of the globe, these theorists have imagined, that the disease must have propagated itself in the bodies of men, and thus have spread by human means from one country to another. This was more particularly the case in the black death, a disease which spread over the whole of Asia and Europe, during the fourteenth century; and when, as it would seem, the doctrine of contagion was first generally broached, and as generally believed.

Now granting, for the sake of argument, that disease, like animate things, can be thus reproduced *ad infinitum*; still the problem which we have now proposed would remain unanswered, for the origin of the epidemic, or the cause of its production in the first person attacked, is not thereby explained. As the formation of man is not the less wonderful, because he is possessed of the power of reproducing his species; so, on the other hand, the spread of these diseases in the manner referred to would not render our inquiry into their origin less important, less worthy of our research, or less difficult of explanation. But here the analogy ceases; for we observe in the one case no particular provision, as in the other, for the production of this effect: while even the advocates of the doctrine of contagion are unable to explain the manner in which the matter of contagion enters the system, or produces its effect —some supposing it effected in one way, and some in another.

Would it not be, therefore, more philosophical to suppose, that to the continued operation of the same original cause must be ascribed the production of the disease in all other instances; or, in other words, its propagation and extension from country to country. Such would appear to be the case, not only to me, but to a number of talented writers and individuals, both in and out of the profession, who, from time to time, have made known their opinions on this subject. It becomes us, therefore, to examine the facts and arguments that have been brought forward by the advocates of the above theory, as well as those which can be advanced against it.

With respect to the doctrine of contagion: "the term," as Dr. Adams has shrewdly observed, "is so frequently brought into use, and discussed with so much ease, that one might think its laws were to be ascertained with the same certainty as the solution of a mathematical problem." But in this, as in many other questions, those who are best informed, adds this writer, are sometimes the most in doubt. This has been more particularly the case with the late epidemic, for the facts which have been presented to our notice, during the prevalence of the epidemic cholera, have set every conclusion drawn from the doctrine of contagion altogether at defiance; while they have, at the same time, shown that the premises upon which this doctrine is founded are false and untenable; as will be apparent by a reference to a few of the phenomena observed during the prevalence of this disease.

In the first place we may remark, that the epidemic has not spread *invariably* along the stream of human intercourse, or by the most common and the principal channels of commercial traffic. While the epidemic was running its course along the banks of the Ganges (to draw our deductions from that region, where the disease was seen in its greatest intensity and degree) it was to be conceived that, admitting the doctrine of contagion to be true, facilities were here afforded for the propagation of the disease. But when the malady had reached the interior of India—and when it was found to prevail equally on the banks of those streams which are dry for many months of the year; and where intercourse and traffic do not and cannot exist—a different conclusion must be drawn. Nothing, in fact, was more common in India than for troops on march to find, or rather to be attacked with the disease when they encamped on the banks of some stream, in the uninhabited districts in the interior of the peninsula. It was impossible, therefore, to refer the origin of the complaint in these particular instances to contagion, or infection; for no source existed whence it could be derived.

So, again, when the epidemic had reached the southern shores of the Mediterranean, in 1823, it was to have been expected that it would thence have extended, like radii from a centre, to every country in Europe, had it been possible for the disease to be propagated by animate or inanimate bodies. The subsidence of the epidemic, however, in that quarter, and the invasion of Europe, by a route along which scarcely any intercourse is carried on, would seem to be confirmative of the opinion, that such diseases are not propagated from man to man. Of all countries in the old world, "Russia," as M. Moreau de Jonnes has justly observed, "seemed to be the least exposed to the irruptions of the epidemic cholera. Of her European provinces, the nearest to the Delta of the Ganges, where the malady first appeared, are 1,200 leagues in a direct line, and more than 2,000 by the track of the ordinary communications. Her situation in the highest latitude necessarily limits the period of the hot season, and produces an extreme degree of cold during the winter; which has the double effect of diminishing the duration, and the violence of foreign contagions—a necessary condition for the existence of which is an elevated temperature. Her commercial relations do not extend to tropical regions, nor even to eastern countries, whence all the pestilential maladies imported into Europe come. Lastly, her population, scattered over an immense surface, and less in density than the inhabitants of Belgium or Lombardy, in the ratio of one to ten, is, in comparison with all other parts of the continent, that which offers the fewest facilities for the propagation of contagious maladies; and yet, such is the course of events, and the uncertainty of human affairs, that the Russian provinces are the first which experience the fierce attacks of the Asiatic cholera; and it is by them that this remarkable scourge first invaded the countries of Europe."* I have given the above quotation from a work written expressly to show the contagious nature of the epidemic cholera, not only to prove my own proposition, viz., that this disease, like all other general pestilences, pursues its own course, uninfluenced by accidental circumstances, or human agency; but also to show, at the same time, that even the advocates of the doctrine of contagion do not attempt to explain many of the anomalies which these diseases present, when regarded according to the above theory.

---

* *Rapport au Conseil superieur de Santé, sur le Cholera Morbus, par M. Moreau de Jonnes.*

One other kind of proof may also be mentioned. It is well known that, in London, the disease was principally confined to particular parts of the town,—as the banks of the river, and more particularly the southern side of the Thames; while also the mortality from the epidemic cholera, in this densely crowded city, only amounted to about 3,000—the very lowest rate that has been observed in any town visited by the disease, and little more than what some cities have lost in a single day, with only one-third the number of inhabitants. Now these facts can never receive elucidation from the doctrine of contagion; for if the disease were infectious, there can be no reason why it should not have been propagated as readily in one part of the town as in the other, especially as cases were not wanting in any situation; for, although the malady prevailed principally in certain situations, no part was entirely free. The difference observed was simply this:—In the locality where the epidemic prevailed in its greatest intensity, two-thirds of the inhabitants of a house, a street, or a district, were cut off or attacked by the disease; while, in the more favoured spots, only one in a house, in a street, or one street in a district, was attacked.

This phenomenon, at present inexplicable, as one author has remarked, was not observed in this spot alone; for Constantinople (where the causes to which the exemption in London had been attributed do not exist) was similarly spared, without its being possible to discover the reason of this mysterious immunity.* That it was not produced from the less intensity of the disease is proved by the fact, that the relative mortality of the epidemic was the same in London as had been observed in nearly all situations: for of two persons attacked one died. As it seems difficult to understand why the inhabitants in one house, or street, or town, should not be as capable of propagating the malady as those in other situations—when, as in London, no means were taken to prevent communication between the sick and the healthy—we must conclude, that the spread of the disease from country to country, and from house to house, is due to other causes than human agency.

It is no less a fact, that the epidemic commenced in the centre of France, and before any of the towns on the frontiers had been attacked: while it was impossible to refer the origin of the disease in Paris to the least communication with an infected town, or with infected individuals. Its simultaneous appearance, in fact, among numbers of individuals at the same moment, and in that class of persons who had the least intercourse with strangers, plainly showed that the doctrine of contagion could never account for the origin of the disease in that capital. "We unhesitatingly avow our conviction," remarks the editor of the *Lancet*—a work, be it observed, that had previously advocated the doctrine of contagion, "that it would be worse than frivolous to discuss the proposition, that some other influence than contagion was concerned—and mainly concerned in the excitement of the disease in the French capital; and has since contributed powerfully and fatally to its propagation."

---

* *Relation du Cholera Morbus de Londres, par Halma Grand, D.M.P.*

Again, it has frequently happened, during the prevalence of the epidemic cholera in India, that certain corps on march have encamped for the night on a particular spot—the men being at the time free from all disease. Before the morning numbers have been attacked with cholera, and many have died. Either from design, or accident, the camp has been broken up, and the healthy and the sick removed to another locality; *this is no sooner done than the disease ceases.* Thus, a light-infantry regiment, returning from the Deccan war to Bombay, was attacked by the epidemic at its bivouac; when an havildar stated to the commandant, that *there was no cholera a* *few hundred yards further on, beyond the Nullah;* the camp therefore was broken up, and the regiment, *carrying the sick along with it*, marched beyond the morbific boundary: and *the plague was stayed.* We are also informed, by Dr. Henderson, that the 13th regiment of infantry, to which he was attached, together with the 38th and 48th, encamped on a low marshy spot, near to Patnago, in 1825; in the morning, one officer was attacked with cholera, and in twenty-four hours twenty men were carried off. On the following day, the corps removed *to a higher ground*, a mile and a half off: *and*, from this time, *no more cases of cholera were observed* in the army. An example of the same kind, but on a larger scale, was afforded by the army under the command of the Marquis of Hastings; which was attacked with the cholera, in Bundlekund, during the first year of the prevalence of the epidemic. This division of the grand army had encamped on the banks of the Sinde, immediately after which, the disease appeared; commencing however in its usual insiduous manner, by attacking only the lowest orders of the camp followers. But in a few days, and as it were in an instant, the disease burst forth with irresistible violence:—"Unsubjected to the laws of contact and proximity of situation," to quote the writer of the Bengal report, "which have been observed to mark and retard the course of other pestilences; it surpassed the plague in the width of its range, and outstripped the most fatal disease hitherto seen in the destructive rapidity of its progress. In the course of a week it had overspread every part of the camp, sparing neither sex nor age, in the undistinguishing virulence of its attacks—the old and the young, the European and the native, fighting men and camp followers, were alike subjected to its visits; and all equally sunk, in a few hours, under its most powerful grasp. It was then wisely resolved by the commander-in-chief to change the encampment, *in search of a purer air and a healthier soil* (the reasons assigned for the measure in the official report); and although the line of march was covered with the dead and the dying — men dropping from their horses, or falling while marching in the ranks, as if struck by a cannon-ball—they succeeded, after a few intermediate halts, in reaching, on the 19th, the high and dry banks of the Betwah, at Erich; *where they almost immediately got rid of the disease:* for not a single severe case occurred after the 22nd. The disease was at its height on the 14th; and in one fatal week, of seven thousand fighting men, seven hundred and sixty-one fell victims to the disease; while it was conjectured that eight thousand of the camp followers, or about one-tenth of the whole, were cut off." Independent of the sudden and simultaneous outbreak of the disease among so large a body of men, and its extension *in a few days* over every part of the camp; the circumstance of its as sudden cessation on the division reaching another and a different locality—*notwithstanding that they* *carried along with them the sick and the dying*—can never be explained by a reference to the doctrine of contagion.

It has also frequently happened in India, that two corps on march have encamped for the night near to each other, but *on different ground.* One corps has been suddenly and immediately attacked with the disease, while the other has not presented a single case. The sick battalion observing this, shifts its encampment, and takes up a position alongside the healthy one; and, although they carry with them the sick and the dying, the disease does not spread to the healthy division: notwithstanding that the intercourse between the two corps has been unrestricted, not only between the healthy, but also between *the sick and the healthy.* Nothing can show more clearly than these facts, that it is places and not persons which are infected in these instances; for as some of the corps thus attacked had never been within the focus of the epidemic before, they could not have carried the germs of the disease along with them from any other or infected source. Nor, on the other hand, could they have derived the disease from any human source on the spot where it first commenced, as it so happened that in many instances they encamped, not in an inhabited, but in an *uninhabited* region.

When a severe and devastating malady commences its ravages in a populous, commercial, and sea-port town, it appears easy to account for the origin of the disease on the doctrine of contagion; for the daily and constant arrival of strangers, and persons coming perhaps from some place on the line of road which the disease happens to be taking, affords ground for supposing that they were the importers of the malady; particularly as it so happens that strangers are generally the first attacked. This circumstance has always afforded to the advocates of the doctrine of contagion one of their strongest arguments; for it has been too generally concluded that such persons must have been in contact, either directly or indirectly, with infected persons or things. But the conclusion drawn in consequence falls to the ground, when it can be shown that the same law holds good with persons who have come from an uninfected, as well as those who have come from an infected, town or country.

Besides, the phenomenon admits of explanation, by a reference to the laws regulating the operation of malaria on the human system. In districts where this destructive agent exists, it is well known that strangers, and persons coming from another and a more healthy locality, are frequently attacked with disease; while the inhabitants remain entirely free. Thus, it is death for a European to sleep for a single night in many of the pestiferous spots of intertropical climates; notwithstanding that the natives reside there with impunity; or, at least, if affected at all by the same malign influence, are not subject to those acute diseases and severe attacks which strangers experience.

It is, in fact, a wise provision of nature, that the human frame should be able to bear, if not with complete, with at least comparative, impunity, the operation of many morbid agents, when slowly and gradually brought under their influence ; although they would produce disease and death in those suddenly exposed to their injurious operation. This circumstance will enable us to explain the otherwise remarkable fact, that, during the prevalence of epidemic diseases, persons coming from other towns (or, in other words, strangers) are often the first affected.—The reason is clear.

From the facts which have been collected, by numerous writers, we are bound to infer, that the epidemic influence, whatever that may be, is in operation for some time (in fact, many weeks—if not months) before it produces any severe effects. This phenomenon was particularly observed during the prevalence of the epidemic cholera; for not only was the severe form of the malady preceded for many days by slight attacks of diarrhœa, but a variety of anomalous symptoms, indicative of derangement in the digestive organs, was observed to prevail for many weeks, before the epidemic manifested itself in its most severe form. To this particular affection the term *cholerine* was applied by the French. As, therefore, the cause, or combination of causes, productive of these effects, seemed to be thus slowly brought into operation (as proved by the mildness of the symptoms first observed, and their gradual increase until the disease was ushered in in its acute form), we may conclude, that those who had been gradually accustomed from the first to the influence of the morbific cause would be longer able to resist its operation, than those who were suddenly exposed to the injurious effects of the same deleterious agent.

On this point I can speak from personal experience; for having followed the epidemic cholera for some years, and having paid frequent and oft-repeated visits to districts in which malaria abounds, it has generally happened, after I have been residing for any time in other and more healthy localities, that I was, on my arrival in an infected district, attacked with the prevailing complaint—no matter whether it was epidemic or endemic; that is to say, the cholera, fever, or dysentery. As, however, this frequently occurred on my first arrival, and before I had seen a single patient, or had come in contact with those who had been in communication with the sick; it was impossible to suppose that the cause of the disease resided in the bodies of men.

Besides, when we remark that a number of individuals, congregated together, are simultaneously attacked with disease; and this, too, suddenly, and, as it were, in a moment; we are at once led to conclude, that the agent productive of these effects is external, and not internal; or, in other words, that the cause is general, and not individual. Hence, certain writers, from the time of Hippocrates to the present day, have ascribed the production of epidemic diseases to some unnatural condition of the atmosphere—such as great heat or cold, moisture or dryness; or, else, to some imperceptible change in the constituent elements of the air, or its electrical state—for it so happens that great and unusual vicissitudes in the weather are always observed at such periods. But the prevalence of epidemics during every known state of the atmosphere—at the time of great heats, as well as during intense cold; in the midst of continued rains, and, also, in the driest summer, or the dry season of a tropical climate—shows, however great the changes and vicissitudes of the weather may be at such periods, that these circumstances are not the cause of the production of the above diseases. For instance, the epidemic cholera broke out in India, and generally returned during the hot season; while in other places, as in Russia, it commenced in the midst of a Siberean winter, and continued its ravages until the warm weather set in. Again; in England the disease first arose in the middle of winter, and returned at the commencement of summer. These facts, and many others that might be adduced, plainly show, that temperature can have nothing to do with the origin, or continuance of the disease. It has also frequently happened, in particular places, as in India (where the phenomenon can be better observed, on account of the regularity of the weather at each particular season, as the rainy and the dry—characterized either by continued rain or unchanging dryness, for a certain portion of the year), that the epidemic has commenced its ravages in one place on the setting in of the periodical rains, and that it has ceased on the commencement of dry weather; while, in another place, the malady has commenced in the middle of the dry season, and subsided as soon as the rainy weather set in Thus, the epidemic cholera first commenced in Bengal at the very height of the monsoon; and when the country about Jessore was covered with sheets of water, from previous heavy rains. But at Chuprah and at Arcot the disease commenced before the rains had set in; and when the weather, for a month previous, had been excessively dry and sultry. In fact, Mr. Davies, in his letter, attributed the origin of the disease in that spot to the extraordinary dry season and sultry weather; for he adds, "we have every reason to trust for the setting in of the rains, which can alone relieve us from the noxious miasmata." The disease, therefore, as was well observed by a writer in the *Asiatic Journal*, having shown itself at Chuprah after excessive drought, and in Bengal, in the midst of continued rains, sets at defiance all theories resting on the state of moisture and dryness of the atmosphere. The same phenomenon has been observed in other countries, in hundreds of instances, since that period.

Again; a change in the electrical state of the atmosphere, especially a diminution of it, has been assigned as the immediate cause of epidemic diseases. But the prevalence of epidemics, during every known condition of the atmosphere, when it is in a state of positive as well as negative electricity, forbids our referring them to the influence of this agent. Besides, the living body, as the writer of the *Madras Report*[*] truly remarks, may be negatively electrified, as well as positively, without suffering more inconvenience in one case than in the other. Instances are frequent of men and animals being even struck down by lightning, and remaining stunned for a time, without experiencing any permanent injury. The animal frame, therefore, seems capable of resisting very great changes in the quantity of electricity, without producing the least injury, or any morbid phenomenon. Independent of the above, again to quote the opinion of the writers of the above valuable report, all the atmospheric phenomena, and other circumstances, brought under the head of occasional causes, have, with little or no interruption, existed from the beginning of time without producing such a disease, at least, during historical periods: the addition of another and a different cause, therefore, must be inferred.

In other instances, however, the cause of these visitations has been ascribed to very different circumstances; for as the use of impure and stagnant water, or bad food, was found at times to produce disease and death among bodies of men or herds of cattle; so, also, it was supposed that to the introduction of some poisonous element, from one or other of these causes might be ascribed the production of epidemic diseases. This inference was strengthened by the fact, that there is frequently a great similarity in the symptoms produced by the ingestion of various well-known and poisonous substances; more particularly septic ones, and those which characterize epidemic complaints. Even in the present day one writer has attempted to prove, that the epidemic cholera was produced by the bad state of the crops of rice; which happened to be affected at the time of the appearance of the disease in Bengal. But it is impossible to suppose that epidemic diseases are produced from either of the above causes; for we have observed them to extend equally over the alluvial and swampy plains of India (the inhabitants of which make use of water contained in tanks, and which remains exposed to the contact of dead organized matter for a great part of the year) as on the sandy and arid plains of Arabia; where the natives drink no other water than that drawn from deep wells, into which substances capable of decomposition cannot possibly enter. Nor, on the other hand, can these diseases be produced from any peculiarity or injurious state of the food partaken of at these particular periods; for we have witnessed epidemics, commencing in one part of the globe, and thence extending in various and different directions, attacking equally the Hindoo and the Asiatic, who live principally on rice; the Russian, whose food is almost entirely animal; the inhabitants of temperate regions, who make use of a mixed diet; and, in fact, prevailing equally among all the different varieties of the human race, whatever be the nature of their food, or their mode of living.

---

[*] *On the Epidemic Cholera.*

But, although unable to account for the introduction of any injurious substance into the system, by the means which have been already considered, we are not the less led to infer, that these diseases are produced by the operation of a poison on the living frame. As a talented writer has justly observed, with respect to one particular disease, and the same remark will apply to most other epidemics, "when we view the essential symptoms of the cholera, when we scrutinize the pathological phenomena, and finally, when we call to mind the effects of numerous poisonous agents, we see sufficient ground at least to admit the possibility of the remote cause being the operation of a poison on the system; and this possibility amounts almost to a certainty, when we remember that all the other causes have been shown to be inapplicable."* We will, therefore, for the sake of argument, take it for granted, that epidemic diseases are produced from the operation of a poison on the system; and pass on at once to a consideration of the source whence it is derived. If unable to account for the introduction of any poisonous and unknown substance into the body, by its combination with the food partaken of by man, we are naturally led to regard, as the medium of its introduction, those elements which pass into the windpipe; the supply of which to the lungs is not only as necessary, but more so, for the health and life of the individual, as food itself. When indeed we reflect that about 40 cubical inches of atmospheric air pass into the lungs at each inspiration, which, supposing that there are 20 inspirations in a minute, would make 48,000, or 1,152,000 cubic inches in 24 hours, ready means would thus be afforded for the introduction into the body of any injurious substance contained in the air we breathe.

---

* *Lancet.—History of the Epidemic Cholera.*

Now we may remark, in the first place, that, although epidemic diseases cannot be ascribed to any sensible or appreciable alteration in the physical properties, or chemical relations of the atmosphere; there are, nevertheless, certain circumstances which would seem to force upon us the conviction, that the agent productive of these effects is sometimes present in the air of those places attacked by the disease.

Thus, it has frequently happened, particularly during the prevalence of the epidemic cholera, in India, that when the disease has commenced, or been prevailing during serene and settled weather, the setting in of the accustomed rains, or the occurrence of a thunder storm, has suddenly put a stop to its ravages. So, again, it was observed in other instances that the epidemic, although progressing regularly against the wind, appeared, nevertheless, to be somewhat influenced by its prevalence or direction. For example: its progress during the south-west winds was slower from Ganjam to Nellore, than it was from the latter district to the remaining southern portion of the coast, *after the wind had set in from the north-east.** These and many other circumstances of the same kind, which might be adduced, would seem to prove, that the morbific agent is present in the atmosphere. But certain writers object to this conclusion: for they observe, the disease in that case could not make any sensible progress against the continued and violent monsoons, nor could villages or tracts of land escape the disease, when all around them were suffering from its effects. So remarkable has this phenomenon been, that, not only was one village attacked, while the next has been spared, but one part of a town has been visited in preference to the other, and even one side of a street, the opposite not presenting a single case. It is impossible, therefore, that the morbific agent, if present in the atmosphere, can be generally and equally diffused in this fluid, otherwise it could not be thus partial and limited in its operations. If so, we must conclude with a writer in the *Revue Médicale*, that, although the air may serve as a vehicle for the dissemination of the germs of pestilential diseases, it is not the source, as we have before remarked, which gives them birth. Hence, certain writers, more particularly those resident in intertropical climates, and who, at the same time, had no faith in the doctrine of contagion, have referred the origin of these complaints to the poisonous element termed malaria, which is known to be given out in great abundance from the soil of particular localities—as the alluvial tracts and deltas of intertropical countries, and the marshes of extratropical ones.

---

* *Madras Report,* page 46.

Now it so happens that many of the phenomena, presented during the march of epidemic diseases, are also common to the effects produced by this invisible but well-known agent. One circumstance is, that although diffused in the atmosphere, this poison becomes innocuous at a short distance from the source whence it is given out; for not only will one part of a particular country be pestiferous, in preference to all other places, but even one extremity of a town, or one street, is found to be sickly, while the others are comparatively or quite healthy. The same phenomenon, as we have just remarked, is observed during the prevalence of epidemic diseases. Again; it has been found in districts where this poison is generated, that its operation is frequently as limited and as capricious as that of epidemic diseases, for the interruption of a forest, a mountain, a high wall, or even a mere cloth, is frequently sufficient to preserve the inhabitants from the pernicious effects of the air charged with deleterious miasmata. Seclusion, therefore, may be beneficial during the prevalence of epidemic as well as endemic diseases, without reference to the doctrine of contagion.

Many other points of resemblance might be adduced; but as they will be alluded to hereafter it is unnecessary to bring them forward in this place. The question at the present moment is, whether, as there are apparently so many points of resemblance between epidemic and malarious diseases, the cause of their production is the same. In order to determine this, we must first inquire in what manner malaria is generated, and in what situations it is found to prevail.

It is supposed by the generality of writers, that this poison is the product of animal and vegetable decomposition—substances known to be present in the soils of those places, from which malaria is extricated in its greatest intensity. Without waiting, however, to ascertain the truth of this theory, we have only to remark, that it is a well-known fact, and capable of demonstrative proof, that a poison, to which the term *malaria* has been applied by Italian writers, and that of *marsh poison* by English ones, is given out from the soil of particular localities, in all latitudes. To those acquainted with the properties of this invisible agent, a great similarity will at once be perceived between the poison of malaria and the poison productive of epidemic diseases, as regards their operation on the human frame. Hence it is that so many writers have attempted to show that the one class of diseases is produced from the same cause as the other. But this cannot be the case if malaria be, as most persons maintain, the product of animal and vegetable decomposition, and if it is only found in situations where these organic remains exist; for we have observed epidemic diseases to prevail equally on the fertile plains and alluvial districts of India, where all the elements necessary for the decomposition of organized matter are found in the greatest abundance, as well as on the sandy deserts of Arabia and the frozen and snow-covered plains of Russia, where a blade of grass is not seen, and where the putrefaction of animal substances is as impossible as the putrefaction of an Egyptian mummy. Nor, on the other hand, can we infer, that the matter productive of epidemic diseases is generated in one spot, and afterwards transported by winds or currents of air to other and distant regions; for epidemics have been observed to progress on, even against the wind. Thus, the epidemic cholera travelled from north to south of the Indian peninsular with remarkable regularity, appearing in the line of 20° of northern latitude, in the beginning of 1818, and reaching 8° north latitude on the 1st January, 1819, being about a degree a month. During this progress, far from being assisted by winds, the disease must have frequently travelled in direct opposition to the currents, and seems never to have been retarded or advanced by their direction. This circumstance was better observed and more particularly remarked in India, on account of the prevalence of particular winds, in this part of the globe, at particular seasons of the year, and their continuance and subsidence for certain and fixed periods. Thus, Captain Sykes, in his letter to Dr. Mylne, detailing the account of the outbreak of the cholera at Punderpoor, remarks, "With respect to the cause, we ought at once to acknowledge our ignorance. It is supposed to exist in the atmosphere, from its pervading everywhere so extensively; but how comes it," adds this gentleman, "to spread in opposition to a continued current of air like the monsoon; for it has made its way against a permanent south-west wind from Taulna to Punderpoor, travelling at the rate of fifteen or twenty miles a-day."

Besides, epidemic diseases have not only attacked bodies of men on the land, but they have also infected ships at sea, at a time when they were hundreds of leagues from the shore, and where of course the operation of a poison from such a source cannot possibly be experienced; for malaria becomes innocuous when largely diluted in the atmosphere. Thus, persons, residing only three or four hundred yards above the level of the marsh or jungle, escape the diseases, which are frequently productive of great mortality among those, who inhabit spots nearer the source whence the poison is given out. If these deductions be correct, it follows, either that the poison of malaria and that productive of epidemic diseases are different, or else, that the former is to be found in other situations than those where animal and vegetable decomposition takes place; and that, consequently, it is generated by other and different causes. Whether this be the case or not I shall not now wait to inquire, as it is my intention to return to the subject on a future occasion. Suffice it, therefore, to observe, that, as we must look to some other source for the generation of the poison productive of epidemic diseases than that usually considered to give origin to malaria, we will confine ourselves on the present occasion to a consideration of the cause, which produces the former element: leaving the latter for another and particular inquiry.

If, however, we infer, that the agent productive of epidemic diseases is present in the atmosphere of particular places, and if also it be concluded, that it is not produced by any alteration in the chemical affinities and properties of the air itself, or generated on the surface of the earth, whence, we may ask, can this invisible substance be derived?

If unable to account for the production of the poison above the surface, our only resource is, to glance into the interior of the globe, with the view of ascertaining whether there is any process going on there capable of giving origin to a poisonous matter. Now there is a process in constant operation in the bowels of the earth, and which gives rise, at particular periods, to certain effects cognizable to our senses: to this process the term *volcanic action* has been applied. But then it so happens, that this process is a silent and invisible one; for we are unable to penetrate into the interior of the globe, and view the operations of nature in this her hidden laboratory. It is impossible, therefore, to ascertain its existence, except by the occurrence on the surface of some of those phenomena, known to be produced by volcanic action. The principal and the most striking of the effects, directly produced by the agency of this cause, are, as is well and commonly known, the volcano and the earthquake. "Now if we contemplate a volcano whilst in a state of vigorous action, the phenomena presented to us are at once so peculiar, and so impressive, that it would seem unnecessary to be at the trouble of defining that which the commonest observer could hardly fail to recognise again, in whatever part of the globe it might fall under his observation. The evolution of smoke and ignited matter from an orifice in the earth, generally situated on the summit or flanks of a conical mountain, the ejection of fragments and scoriæ, bearing a near resemblance in their condition and aspect to the ashes of an iron foundry, the sudden and copious extrication of elastic fluids, with their natural concomitants, noise, and concussion of the rocks, through which they force their way, are circumstances, which strikingly impress upon the imagination the paroxysms of volcanic action; and appear to distinguish this from all the other operations of nature."* But as the shock of the earthquake, and the eruption of the volcano are the principal signs we have of this action being in existence, the only direct evidence, it may be considered, that could be adduced in support of the above hypothesis, would be the occurrence of these phenomena simultaneously with the outbreak of epidemic diseases. Such proof, however, is generally wanting; for although, as will hereafter appear, epidemics are sometimes accompanied by earthquakes, these diseases frequently prevail without being preceded or accompanied by this phenomenon—while the influence of volcanos must be too limited to allow us to draw any deductions from this source, in respect to general plagues or epidemics.

---

* *Ency. Metrop., Art. Geology.*

" If, however," as the author before quoted truly remarks, " we limit our view of volcanic action to the phenomena attendant on the eruption of a volcano, and the shock of the earthquake, we exclude from our definition a series of effects evidently allied to the former, and, perhaps, equally illustrative of its real nature. How different, for example, are the eruptions of Vesuvius and Ætna, or any other mountain which emits a stream of lava, or melted matter, from the emanations of gas and vapour, which arise in situations where no vent exists, or from the increased temperature of certain springs in the neighbourhood of active and extinct volcanos, or the evolution of carbonic acid, and other gases, from the water of these as well as all other thermal springs. Yet the connection of all these phenomena with the action, which gives rise to the eruption of the volcano and the discharge of melted matter from the crater, is as well established now, as is the relation of subterranean concussions or earthquakes with the volcanic process."* But, although these various phenomena may, when present, afford conclusive proof of the existence of volcanic action, we are unable to derive any evidence from this source in support of our hypothesis — for these effects are seldom witnessed, except at periods subsequent to the appearance of the volcano or earthquake, and in spots, where these phenomena have been observed; or where evidence exists of their former occurrence. Besides, these particular effects are only met with in certain localities; being scattered like the volcano itself, irregularly over the earth's surface, while they occupy but a very small portion of the habitable globe. If, therefore, epidemics extend over every part, and in situations either before the occurrence of the shock, or else, where this and the other phenomena indicative of volcanic action are not observed at all, it follows, that we can derive no evidence in proof of our hypothesis from the existence of the latter, any more than the former signs of volcanic action.

True, there are certain other and general phenomena, which usually accompany the march of these pestilences, and which it will be my endeavour to show hereafter are effects of the same cause; but as these phenomena are not now considered to be signs of the existence of volcanic action, it would be wrong to draw any conclusions from this source, until some other and more positive proofs are obtained in support of this hypothesis. We must, therefore, adopt another and a different method in order to prove the proposition which we have before started.

---

* *Ency. Metrop., Art. Geology.*

Now, the first thing, as Sir John Herschel informs us, that a philosophical mind considers, when any new phenomenon presents itself, is its explanation or reference to an immediate producing cause. If that cannot be ascertained, the next is, to generalize the phenomenon, and to include it, with others analagous to it, in the expression of some law, in the hope that its consideration, in a more advanced state of knowledge, may lead to the discovery of an adequate proximate cause.*

The same advice has been given by Laplace, in his *Essai Philosophique sur les Probabilités;* for he says, "*La méthode la plus sure qui puisse nous guider dans la recherche de la vérité, consiste à s'elever par induction des phénomènes aux lois, et des lois aux forces.*"† This is, in fact, the inductive method of philosophizing invented by Lord Bacon, and applied with so much success to every branch of science by a number of philosophers, who have followed in the path marked out by this prophet of the art, or father of experimental philosophy, as he has been justly termed. Before his time, philosophers were in the habit of pursuing a course, that was subsequently adopted by Descartes, viz., to guess at the cause, and then endeavour to account for the effects by a reference to this power or agent of their own creation. This is very different from Bacon's method, for he says, "MAN, THE SERVANT AND INTERPRETER OF NATURE, UNDERSTANDS AND REDUCES TO PRACTICE JUST SO MUCH AS HE HAS ACTUALLY EXPERIENCED OF NATURE'S LAWS; MORE HE CAN NEITHER KNOW NOR ACHIEVE."* Instead, therefore, of proceeding from causes to effects, he pursued a directly contrary order; and proceeded upwards from effects to causes; or, as he termed it, raising axioms from particular instances.

---

* *On the Study of Natural Philosophy.*

† *Forces* or *causes*—primary, or remote cause as it is now usually termed.

Now, if we generalize the phenomena attendant on the march of epidemics, we shall find that they are so regular and uniform, as to deserve to be set down as laws of the disease. More than this, if we compare these laws with those attendant on volcanic action, we shall find that they are the same, or similar, as will be apparent by the recital of a few of the principal phenomena observed during the operation of this process on the crust of the globe.

THE FIRST AND MOST SINGULAR LAW WHICH

---

* *Novum Organum Scientiarum.*

MAY BE NOTICED, IS THAT WHICH CAUSES THE EFFECTS OF VOLCANIC ACTION TO BE FELT OR WITNESSED ALONG PARTICULAR LINES OF THE EARTH'S SURFACE.

To be convinced of this, we have only to cast our eyes over any one of the principal volcanic regions, when we shall remark, that a series of vents extends along, at no great distance from each other, either in a straight or curvilenear direction; and this too over considerable portions of the earth's surface. As an example of the first, we may refer to the Andes, where, from Chili to the north of Mexico, there is a line of volcanos, *so uninterrupted*, that it is rare to find an intervening degree of latitude, in which there is not an active vent; and it seems probable, that they will hereafter be found to extend from Cape Horn to California, or even, perhaps, to New Madrid, in the United States—a *distance as great as the pole from the equator.** Although extending to this distance in one continuous and uninterrupted line, the volcanic action, as well as the effects resulting from it, is confined to very narrow boundaries on either side. "In regard to the eastern limits of this region," observes the same writer, "they lie deep beneath the waves of the Pacific, and must continue unknown to us." On the west they do not appear to be prolonged to a great distance, for there seems to be no indications of volcanic disturbance in Guinea, Brazil, and Buenos Ayres.

---

* *Lyell's Geology.*

"A remarkable example of the other variation or curvilinear direction, is to be found in the Pacific Ocean. From the Phillippine Islands, a range of volcanic vents proceeds to nearly 10° latitude, ranges westward along this parallel for about 25° of longitude, and then turns up north-west diagonally through about 125° of latitude. This line, which, when represented on maps, resembles an enormous fish-hook, passes from the Philippines, by the north-east point of Celebes, Gelolo, the Volcanic Isles between New Guinea and Timor, Floris, Sumbawa, Java, and Sumatra to Barren Island."

The paroxysmal convulsions, and other signs of internal action along these particular lines, and the fact, that two vents are seldom in a state of activity at the same time, while the discharge of matter from one outlet, invariably lessens, or arrests, that from another, sufficiently attest their continuity beneath the surface. Thus the volcanos in different parts of Iceland, as well as those in the Phlygrœan Fields, are observed, as Lyell states, to be in activity by turns,—one *vent often serving for a time as a safety valve to the rest.* Another proof, also, of the connection of certain volcanic vents, may be adduced from the fact that when several cones are thrown up in one eruption, which is sometimes the case, they invariably take a linear direction.

The principal volcanic region in the old world extends from east to west for the distance of about 1,000 miles from the Caspian Sea to the Azores. From south to north it reaches from about the 35th to the 45th degree of latitude. Its western limits, says Lyell, are the ocean, but it is impossible to ascertain how far it may be prolonged in that direction; neither can we assign with precision its extreme eastern boundaries, since the country beyond the Caspian, and sea of Arat, is scarcely known.

An attentive consideration of the phenomena which have been observed in this part of the world, from time to time, leads distinctly to the conclusion, that the volcanic action extends along the centre of this region in a line from east to west; for while the effects of earthquakes, which have occurred at a given point, have been felt hundreds of miles from the centre of concussion, in *a linear or western direction*, scarcely any effect has been observed in places situated but a comparatively short distance to the north or south of this particular line. This phenomenon was particularly noted in the earthquake, at Lisbon; for the concussion was severely felt by ships at sea, hundreds of miles to the westward of the spot where it first commenced; while places but slightly removed from this line to the north and south experienced no shock, but only slight agitation in the waters of the sea, rivers, ponds, etc. It would also be an easy task to show, if space were afforded for the purpose, that the concussions which have been felt in this region, and even at the farthest extremities of the volcanic boundaries have an intimate connection with the volcanos of Ætna and Vesuvius, inasmuch as for some time previous to an eruption of these mountains, earthquakes have generally been experienced along some portion of this particular line, and which have invariably ceased, as soon as the melted matter has found its way to the surface.

In other instances, however, or, in other districts, where no volcanic vent exists, and where concussions are alone observed, the same law is found to prevail. Thus, a shock having been experienced at a given spot, it is speedily propagated to another and a distant point, *and always along some particular and well defined line*, being frequently felt hundreds of miles from the part, where it first manifests its effects; while places removed only a short distance from this line on either side, are scarcely, if at all affected. Thus, in the earthquake at Chili, the shock was felt *simultaneously* throughout a space of *one thousand two hundred miles* from north to south; while places situated a few miles only on each side of this particular line, were not at all affected. Again; on the 17th February, 1827, a violent earthquake was felt at Santa Fé de Bagota, in Columbia; and *on the same day* at a town in Siberia. It is worthy of remark, adds M. le Baron Humbolt, to whom we are indebted for this account, that the direction of the shock in Columbia was from south-east to north-west, and that this direction points towards Siberia. Not less interesting is the circumstance, that the line from Columbia towards Siberia strikes the most remarkable volcanic region in Mexico, and is parallel to the principal range of American mountains. This may be received as a proof, says the above writer, *that the operation of earthquakes is propagated in a linear direction:* while, also, I may add, it is no less a proof that their effects are felt, at the same moment, over large portions of the terrestrial sphere. Many other examples might be brought forward in proof of the correctness of this opinion; but the above are, it is hoped, sufficient; especially as a remarkable one will be adduced hereafter, in detailing the particulars of an earthquake, which took place in India, in 1819.

In the diseases under consideration one of their most characteristic features is their progression along particular lines. Although, like a range of volcanic vents, they frequently extend over the whole, or a considerable part, of one of the great circles of the terrestrial sphere, yet their effects are felt but at a comparatively short distance on either side of this particular line. So defined is the boundary, which marks their course, that it has not been an unfrequent occurrence (as we have had abundant proof during the march of the epidemic cholera) to observe one side of a river affected, while the other has remained untouched; nay even the same morbific line has intersected a town, attacking a suburb to the exclusion of the city; or one side of the street in preference to the other.

In the black death of the 14th century (the most destructive plague of which we have any record), this law was particularly striking and well marked. This disease, as appears by the unanimous testimony of all historians, first commenced in China; or, according to Dr. Mead, in the kingdom of *Cathay*, to the northward of China; and then spread in a westerly direction across the continent of Asia to Constantinople. We are not acquainted with its exact route in this part of the world: but we are told, that India was nearly depopulated: while Tartary, the Tartar kingdom of Kaptshack and the contiguous countries were covered with the dead. It is also certain, from the records yet preserved, that the plague which broke out in Constantinople in the year 1347, was the same as that, which previously prevailed in the countries to the east of this remarkable city; for the historians of that period state, that the disease had been brought from the northern coast of the Black Sea; or, according to the general Byzantine designation, "from the country of the hyperborean Scythians," after having depopulated the countries between those routes of commerce. When, however, it had reached Constantinople, the grand centre at that period of commercial intercourse, the disease, instead of spreading, like radii from a centre, in all directions, took one particular and well defined course by the islands and shores of the Mediterranean; until it reached the south of France. At this point the epidemic, changing its direction, from a westerly to a northerly one, passed through France and England, and from this to the northern kingdoms of Europe,—Sweden, Norway, and Russia being visited in succession. "Instead of advancing in a north-westerly direction from Tauris and from the Caspian Sea, it had thus made the great circuit of the Black Sea by way of Constantinople, southern and central Europe, England, and the northern kingdoms, before it reached the Russian territories." During the whole of this route we shall find that the principal ravages of the disease were experienced along a line of no great width; and that places, situated beyond the morbific boundary, either did not feel the effects of the disease at all, or else only experienced them to a very slight extent.

In the epidemic cholera, also—a disease which, like the former, had its origin in Asia, and which traversed the peninsula of India, and the heart of Persia by one peculiar and principal route to the borders of the Caspian Sea—the same law was observed. Instead, however, of following in the track of the black death from this point, and extending itself along the shores of the Mediterranean, it proceeded in a north-westerly direction into the heart of the Russian dominions. From this, taking a bend to the southward, it traversed Poland, Prussia, and Germany, by a peculiar and well marked route, until it reached England and France, and at a later period Portugal, Spain, the south of France and Italy; thus taking from the borders of the Caspian Sea the contrary course to that pursued by the preceding disease. This circumstance is the more remarkable, inasmuch as the disease had reached by another branch, or offset, the eastern and southern shores of the Mediterranean as early as the year 1823; and Egypt in 1831; whence it threatened the isle of Cyprus on the one side, and Italy and Greece on the other. These countries, however, entirely escaped at that period; thus proving, most satisfactorily, that this epidemic, like most others, pursued its own peculiar and well marked course, independent of human assistance, and apparently against the stream of commercial intercourse.

ANOTHER LAW, CHARACTERISTIC OF THESE DIFFERENT PHENOMENA, IS THE REGULARITY OF THEIR PROGRESS BOTH CHRONOLOGICALLY AND GEOGRAPHICALLY.

Although this rule is not so evident with regard to the formation of volcanic vents, on account of the want of historical data, in such instances, their production being frequently the work of ages, it is yet sufficiently clear to cause it to be set down as one of the laws of volcanic action; for the vents along a particular line are not formed at once, but in succession.

But it is from the minor effects of the same cause that we have the best evidence of the progressiveness of volcanic action. Thus earthquakes are experienced, not only in places where no volcano is afterwards formed, but, also, at periods long anterior to any eruption. When, therefore, we observe concussions of the earth commencing in some particular point and afterwards extending gradually and slowly, over a considerable portion of one of the great terrestrial spheres, we have a right to infer, that a new volcanic line is forming in this particular direction, more especially if it appears that concussions were unknown, or not frequent, in such situations before this period. Two instances of this kind have occurred during historical periods; for we have observed in the 14th and 19th centuries earthquakes commencing in the east, and thence extending gradually to the west, along particular and well defined lines of the earth's surface. This will be apparent by a reference to the histories that will hereafter be given of the black death and epidemic cholera; as we shall find, that simultaneously with the commencement of these diseases there were experienced severe and remarkable concussions of the earth, as well as other signs of the existence of volcanic action; and which gradually extended over Asia and Europe, in the same direction and along the same lines as those taken by the diseases themselves.

As respects diseases, the regularity of their progress is such that their appearance in a particular spot has been predicted, with accuracy, long before the expected period. Thus Dr. Hecker, narrating the particulars of the breaking out of the black death in different parts of Europe, remarks: "The precise days of its eruption in the individual towns are no longer to be ascertained: *but it was not simultaneous;* for in Florence the disease appeared in the beginning of April; in Cessena, the 1st of June; *and place after place* was attacked throughout the whole year: so that the plague, after it had passed through the whole of France and Germany (where, however, it did not make its appearance until the following year), did not break out till August in England; where it advanced so gradually, that a period of three months elapsed, before it reached London. The northern kingdoms were not attacked until 1349—almost two years after its eruption in Avignon; and in Russia it did not make its appearance until 1351—more than three years after it had broken out in Constantinople."

The same law has been found to hold good with respect to the epidemic cholera, for it progressed with great regularity from the peninsula of India to the shores of America. In consequence, however, of the immense mass of observations, which has been collected from different quarters of the globe during the prevalence of this disease, we are enabled to add what was not before ascertained, or noted, in all probability, viz.,—that, although the progress of the disease has been exceedingly regular in a particular locality or country, its rate of progression has varied much in different situations. Thus, after leaving the Delta of the Ganges, its rate of travelling was very uniform, across the whole of the peninsula of India,—along the northern coast it was about a degree a month. But, although it only took a year to traverse the distance from Calcutta to Bombay, it was three years extending from the southern to the northern parts of Persia; while, in Russia, it traversed the immense distance of 700 leagues, from the borders of the Caspian Sea to the shores of the Baltic, in the short space of six months. But, notwithstanding this difference in different localities, its rate of progression, in the same country, or district, and in different countries, *characterized by the same geological features*, was singularly uniform; as any one may convince himself by referring to the date of its arrival in each successive town in the various portions of the globe visited by the disease. The cause of this apparent anomaly we shall refer to presently.

There is, also, another circumstance well worthy of attention, in considering the rate of progression of these different diseases; which is, that, although varying so much in different situations, their progress along the whole of the track pursued by them appears to be about the same, when different epidemics are compared together. Thus, the black death took 14 years to reach the confines of Europe, having commenced in China in the year 1333, and breaking out in Constantinople in 1347. From this point it gradually spread by the route before described to the northern parts of Europe, which it reached in 1351, or four years after its appearance in Constantinople. Now, it so happens, that the epidemic cholera was exactly 12 years travelling from the extremity of India to the confines of Europe; for it commenced in Bengal in the year 1817; and broke out in Astrakan in 1829; although it did not spread beyond this locality until the following year. From this point the disease pursued a different route to that taken by the black death; as it visited the northern kingdoms of Europe first, and the southern last. Notwithstanding, it is a remarkable fact, that the latter epidemic took about the same time to perform this circuit that the former did to complete the other route; for the cholera appeared in the countries bordering on the Mediterranean five years after its commencement in Astrakan, on the borders of the Caspian Sea—while the black death reached Russia four years after it had broken out in Constantinople.

Such facts would be perfect anomalies, when explained by the doctrine of contagion, as no reason can possibly be given, why the disease should have been propagated as speedily in the one case as in the other; for the commercial traffic, and intercourse in the whole of these countries, must have been widely different in the 14th and the 19th centuries.

ANOTHER LAW REGULATING SUBTERRANEAN

ACTION, IS, THAT ITS EFFECTS ARE LESS ON SECONDARY THAN ON TERTIARY STRATA; WHILE THEY ARE SELDOM WITNESSED ON PRIMARY FORMATIONS.

Thus, the most common effect of volcanic action, the earthquake, occurs in general on tertiary formations, while the shocks are felt more severely in the deltas and alluvial tracts at the mouth of rivers. It is also observed on secondary formations: but its effects are then more limited; while, on primary formations, the earthquake is still more rare, and less severe. The more rare effect of the same action, viz., the volcano, is, on the contrary, generally observed on secondary strata; being seldom found on primary formations; there being only one exception, I believe, to this rule, viz., the volcanos of Chili.

The same law applies, with equal force, to the march of epidemic diseases. Like the effects of subterranean action, they are comparatively rare on secondary strata; and almost entirely unknown on primary formations. Numerous examples of the truth of this observation may be found in the history of the epidemic cholera; for the fact of the virus showing an unwillingness to ascend high and mountainous tracts of country was noticed in the Bengal report, at the very commencement of the epidemic. Now, although it must be confessed, that many of the mountainous tracts, which then escaped, have since been ravaged by the disease, yet it might be seen, even in these instances, as Mr. Jameson remarks, that high lands were not congenial to it; for the epidemic was generally raging with great violence on the plains below, at the very time that the hilly and mountainous tracts were only slightly affected by the malady. But, notwithstanding that the disease subsequently ascended the first and lowest ranges of the Himalaya, it has never been able to pass the centre of this primitive chain, even to the present day; for it was by another and a different route that the epidemic reached Asia Minor and Europe.

Again: The greater prevalence of these diseases on tertiary strata, in alluvial tracts, and on the deltas of rivers, is so generally and so well known, that writers of various and different opinions have ascribed the origin of these complaints to malaria, or some other poison, generated in such situations, being afterwards propagated by particular channels or certain means, as contagion, to other and distant parts of the globe. Numerous examples of this kind have been adduced, in a preceding part of this paper, and which prove not only the greater prevalence of the disease on low and swampy soils, but, also, the remarkable fact, that the removal of the sick and the healthy to higher ground was sufficient to prevent the extension of the disease.

With regard to the difference, which the disease exhibited in different localities, we may refer for an example, on a large and grand scale, to the mountainous regions of Persia, or the Caucasus, and the vast plains and alluvial districts of Russia. It was in 1821 that the disease first attacked the towns situated on both sides of the Persian Gulf, whence it spread slowly and gradually by the route already mentioned to the shores of the Caspian Sea; which it reached in 1823. But there was a striking diminution in the violence and intensity, as well as the extension of the malady, as it proceeded northward, and gained the defiles and mountainous tracts of the Caucasus—a circumstance that cannot be ascribed to the paucity of the inhabitants in these districts, as the malady extended itself, at the same time, to the large and populous town of Astrakan, where the visitation was as mild, and subsided as quickly as in other and more thinly inhabited regions. From this time the malady continued to prevail every summer, to a slight extent, in the north of Persia, and the southern borders of the Caspian Sea, until the year 1829: when it appeared to have gained fresh strength; for it suddenly extended itself in a northern direction; and a second time attacked Astrakan. After cutting off 4,000 persons, in the town, and 21,000 in the province, the epidemic proceeded with unprecedented velocity through the heart of the Russian dominions, committing great havoc among all classes of the natives, *in the thinly inhabited districts* as well as in the most populous. In the spring of the following year it again reappeared, and extended itself through Poland and Germany with inconceivable rapidity; having reached Berlin in August, and Hamburg in October.

By a reference to any geological map of Europe, (as that in the *Encyclopædia Metropolitana*), it will be seen, that the tract of country traversed by the epidemic, with such rapidity, forms one single and immense tertiary deposit; being bounded to the south by a chain of primary mountains through a great part of its extent. This barrier, here as elsewhere, was sufficient to prevent the spread of the disease in that direction; for, although extending along the whole of this plain from east to west, the disease was not seen on the southern side of this range of mountains,—as Switzerland, which is situated in the midst of the chain, not only escaped then, but has, I believe, continued free from any visitation of the epidemic up to the present time. One exception occurs to the above, and that is the kingdom of Austria, which is situated to the south of this range of mountains. But, then, it will be seen, that the district thus referred to is not situated on primary formations; as a tract of country, extending from the Black Sea as far as Vienna (and which is somewhat broad at the base, or to the east, and narrow at the apex, or towards the west), is marked in the map as tertiary. Now it was precisely over this tract of country that the disease spread; for the epidemic, after reaching the borders of the Caspian Sea, extended itself in two different directions, one by the route before described, and another along the northern borders of the Black Sea, to the mouth of the Danube, along whose banks it extended itself as high up as Vienna. But although the disease had thus again reached the boundaries of Switzerland, by another route, this country still continued free, for the epidemic did not spread any further in this direction. Nothing can show more forcibly than these facts the influence of locality on the continuance and propagation of the disease.

THE NEXT LAW TO BE MENTIONED AS REGULATING THE EFFECTS OF VOLCANIC ACTION ON THE SURFACE IS, THAT THEY ARE ALWAYS MUCH GREATER, AND MORE PERCEPTIBLE NEAR THE SEA, AND OTHER COLLECTION OF WATERS, AS LAKES, RIVERS, SPRINGS, ETC.

Thus, the volcano is never witnessed except near the sea, or great inland collections of water. Even those volcanos which lie inland, says Lyell, form part of a chain of volcanic hills, and may be supposed to have a subterraneous communication with the extremities of the chain, or those volcanos which are near large masses of salt water. The neighbourhood of the sea, therefore, seems one of the conditions necessary for the ascent of lava to great heights.

Again: Whenever an earthquake (for the volcano is entirely a local phenomenon) is experienced, the shocks are always more perceptible in the sea, in lakes, and springs, than on dry land, being frequently observed in the former when no effect has been perceptible in the latter. A memorable example of this was afforded during the great earthquake which occurred at Lisbon, in the latter part of the past century, when a wave was produced, which extended to the shores of England and Holland, as well as other places farther removed from the centre of concussion. But independent of this effect in the waters of the ocean, which can be readily accounted for when it is known that a wave 60 feet high rose at Lisbon, similar disturbances were felt in the water of lakes, canals, and ponds, both in Holland and England,—situations altogether removed from any, or the least communication with the sea. Thus at Bilborough, in Derbyshire, between 11 and 12 o'clock at noon on the day when the above earthquake occurred, a surprising and frightful noise was heard near a large body of water called Pilby Dam, and a swell which came in a current from the south rose two feet on the north side of the lake. At Loch Lomond, in Scotland, the water, without the least apparent cause, suddenly rose against the banks to some considerable height, and then as suddenly subsided far below their usual level. At Eaton Bridge, Kent, the water of a pond was observed to open in the middle, so that a post, *before covered with water*, could be seen a great way down, almost to the bottom. The same and similar phenomena occurred in many other parts of England, and in various parts of the continent, even in the north of Germany, although the concussion itself did not extend far to the northward of Lisbon.

So frequently do epidemics make their appearance at the mouth of some river, and so invariably are they propagated along the banks of those streams, at whose mouths they appear, that this circumstance has afforded the advocates of the doctrine of contagion one of their strongest arguments; as it is generally in the course of rivers that commercial traffic is the greatest, and human intercourse the most regular, and the most frequent. Thus the epidemic cholera first broke out on the banks of the Ganges, and ascended by the course of this stream to the interior of India. So, also, when it commenced its ravages on another continent, it proceeded, after attacking the towns on the borders of the Persian Gulf, by one route, slowly and with apparent difficulty, through the arid tracts and mountainous regions of Persia, as far as the Caspian Sea; while it proceeded by another route, with the greatest rapidity, along the banks of the Euphrates and Tigris to the Mediterranean. Again; when the disease reached Astrakan it proceeded with unprecedented violence along the banks of the Volga, until it reached Moscow on the one hand and Petersburgh on the other. In another direction the disease pursued the course of the Don, until it reached Sebastapool on the Black Sea; while it was along the banks of the Danube that the epidemic proceeded towards Vienna, and ascended to the rest of the Austrian dominions.

It is, also, worthy of observation, as showing the local origin of the disease, that, although epidemics prevail most in tertiary formations, and although they extend with greater rapidity in the course of rivers, than in any other direction, they have not always commenced at the mouth of these streams, or at the point to which commerce and traffic happen to verge in that particular locality; notwithstanding that these situations were in the direct route which the disease was pursuing, and notwithstanding, that the towns at first passed were subsequently attacked. Thus, the first case that occurred in England was not at Sunderland, or any other part of the coast, but some distance in the interior; while the individual, it was proved, could have had no communication with persons coming from an infected spot. So, also, when the disease reached Russia, instead of commencing as we should have concluded it would, in Astrakan, a large and populous town on the sea coast, it broke out at Orenburgh, a town situated on the banks of the Ural, 400 *miles* north of the Caspian. Every attempt to prove the importation of the disease into this place having failed, we must conclude that when the malady reaches any alluvial tract, it selects that town the situation of which is most exposed and the best fitted to receive the impression of the pestilential virus; no matter whether it be at the mouth of a river, or whether it be in daily communication with other and previously infected districts.

Next to the alluvial tracts and banks of rivers, epidemics have always prevailed most near inland collections of water, as lakes, ponds, etc., while their greater prevalence in the neighbourhood of particular springs, when compared to other situations, has doubtless given rise to the popular opinion so frequently, and we may say generally, entertained during the prevalence of every epidemic, that such waters had been rendered deleterious by human agency.

THE LAST LAW COMMON TO THESE DIFFERENT PHENOMENA, WHICH WE SHALL NOW CONSIDER, IS, THEIR LIMITED DURATION; THEIR PERIODICAL RETURN; AND THEIR TOTAL CESSATION IN THAT PARTICULAR LOCALITY AFTER CERTAIN DEFINITE PERIODS.

Thus, volcanos only throw out lava for a short period, as a few hours, or a few days, although the minor products of the same process, or aqueous vapour and gazeous substances, continue to be evolved for a much longer time, as several months. When, however, a vent has been once formed in any locality, eruptions are sure to be experienced from time to time, in the same spot, although the period of their return varies much in different situations. The same circumstance is observed with regard to earthquakes, except that they return more frequently, and at shorter intervals than the eruption of the volcano; for although the duration of a single shock is seldom more than a few minutes, still a succession of shocks is sometimes felt in the same spot for many weeks, or even months. They then subside entirely, for a period which varies under different circumstances, when they again return, and again subside, to reappear after another interval; for *the same continuous tracts*, as Lyell justly observes, are agitated again and again. In some situations they are found to return at regular and fixed periods, or months in the year, more particularly the summer season. When, however, these effects have continued for a period, which varies under different circumstances, they are found to cease entirely in the district, or part of the globe, where they have been observed. It has been this circumstance which has caused volcanos to be divided into active and extinct; or those which are subject to occasional eruptions, and those which have not been observed to throw out lava, or gazeous matter, during historical periods. Numerous groups of the latter are scattered over the earth's surface the same as the former; and, in these situations, not only does the volcano remain in a quiescent state, but concussions, and other signs of volcanic action are also wanting. This may be received as a proof that the volcanic process is not permanent; but that it has its rise, fall, and total cessation, in each district, or spot, where it prevails.

The same phenomenon is characteristic of epidemic diseases, for they never continue to prevail during one eruption for more than a few months or weeks, although we may witness returns of the same epidemic for many years, either at regular or irregular periods. Thus, according to M. Moreau de Jonnés, the longest period during which the epidemic cholera has continued in any particular town, or locality, is 114 days, and the shortest 20. But its duration was even less than this in the east, for in the upper provinces of India it seldom remained in a town or district more than 10 or 15 days. What the duration was of the black death in the east, we have no accounts; but, in the west, it seems to have remained during each visitation about the same period as the epidemic cholera, or, perhaps, rather longer.

Both diseases, also, have been observed to devastate the same tracts over which they first passed, at particular, or irregular, periods. Thus, in Europe, the black death continued to return at certain intervals, and to prevail epidemically for some centuries. With respect to the epidemic cholera, although we have had no returns of the disease, in an epidemic form in Europe, since the first years of its appearance, it has, nevertheless, continued to appear in India from time to time up to the present period; with this difference, however, that instead of extending over the whole continent, it has only attacked particular towns or provinces at each successive visitation. But, although it has not reappeared in Europe in an epidemic form, there are, I believe, few places in which isolated cases have not been observed from time to time; thus showing that the cause productive of the disease *is still in operation*, at particular periods, in this quarter of the globe, although to a less extent than in the former. Thus, there were three cases of malignant Asiatic or blue cholera in Madrid the year after the appearance of the epidemic in that city; of which I can bear personal testimony. Two of those cases proved fatal, yet the disease did not spread in consequence. The same occurrence has been witnessed in many other towns, almost every year since the appearance of the epidemic in Europe; of which numerous instances could be adduced.

But what appears most singular is, that in some cases the disease has appeared in an epidemic form, not confining itself to a few individuals, but prevailing generally in a town. This was the case with some towns in Spain,—as Rosas, in Catalonia, and a few others; and although the disease assumed a severe form, it did not spread, as in former years, to other districts. The same thing occurred in England in 1838, when the epidemic prevailed rather extensively in Coventry. Such facts are alone sufficient to prove the spontaneous origin of the disease, and its reproduction independent of human agency; for it was impossible, in these instances, to suppose that the disease could have been imported, or that it was at all contagious, otherwise it must have spread to the neighbouring towns the same at those periods as at others, especially if it had been one-half as infectious as the advocates of the doctrine of contagion *were obliged* to make it, in order to account for its extension, under particular circumstances, and in certain situations.

That the disease will continue to return in the same way, to a greater or less extent, for some time, perhaps for one or two centuries, and that it will cease entirely, at some definite period, over the whole globe, we may presume, from the history of other plagues or epidemics. Thus, the black death, which broke out in the middle of the 14th century, returned, as we have just stated, at regular periods, and prevailed extensively, in Europe, until the middle of the 17th century. It then ceased entirely in every part of the world, excepting Turkey and Egypt, where the same, *or a similar*, disease prevails in the present day: for on this point, or the identity of the two diseases, there may be a difference of opinion with different individuals. That the black death should continue to prevail in these districts for a longer period than in others need not excite much surprise, for it is precisely in these situations that the manifestations of volcanic agency are the most apparent—the Mediterranean Sea and contiguous countries forming one vast theatre of volcanic action. The continuance of the disease, therefore, in this locality, will not invalidate the above conclusion; as we may infer, that, when the volcanos of Ætna and Vesuvius become extinct, the plague of the Levant will also cease to be observed.

That the subsidence of the plague in Europe is to be ascribed to some single and specific cause, and not to any external or accidental one—such as the advancement of civilization and a consequent change in the habits and mode of living of the inhabitants, on the one hand, or the establishment of quarantine on the other, may be inferred from the fact, that the disease subsided about the same time in *all* the countries north of the Mediterranean; the same, indeed, in those which had made a small, as in those which had made a great advance in civilization; in those where quarantine was *not* established, and in those where this presumed safeguard was adopted. The subsidence of the plague in London, also, was supposed to be due to the purifying effect of the great fire, which took place in the middle of the 17th century. But, as the disease ceased to be observed about the same period in all the other countries in Europe, we must regard the occurrence of the above calamity as a coincidence merely, and not as a cause.

Having thus shown, that the laws, which regulate the effects resulting from volcanic action, as manifested on the crust of the globe, and those, which govern the duration and progress of various malignant diseases, are similar, it must follow, either that these various phenomena arise from two different causes, governed by the same laws; that the one set is an effect of the operation of the other; or, lastly, that they are the common effects of one common cause.

When we remark, however, that these effects are so varied and dissimilar, it is difficult to conceive, how different causes could give rise to phenomena which, varying both in kind and degree, should observe exactly the same laws. That, on the other hand, the one set of phenomena is the cause of the production of the other, we might at first sight be induced to infer from the remarkable fact, that epidemic diseases seldom prevail to any extent, or for any period, without being accompanied by concussions of the earth. This circumstance has been particularly dwelt upon by Noah Webster, in his History of Epidemics; for he says, "it has been ascertained, beyond all question, that the periods of extensive pestilence and mortality are remarkable for earthquakes and eruptions of volcanos." But the explosions, he adds, do not so generally precede epidemics, as to authorize the supposition that they produce these diseases. "Earthquakes occur during the prevalence of pestilential or other mortal epidemics, but generally in the midst of the period, or sometimes at the conclusion." In fact it more frequently happens, that the concussion occurs on the termination of the epidemic than at any other period —a circumstance that has been remarked by many writers. Thus Van Swietan says, "when the plague raged at Ockazon, on the very day the distemper began to abate a violent earthquake happened;" and he at the same time asks, "Did anything exhale from the earthquake antidotal to the contagion of the plague?"* Independent of the above, it does not always happen that earthquakes occur in the seat of pestilence, especially during the prevalence of general epidemics; for extensive tracts are frequently ravaged without such a phenomenon being observed. As it is clear, therefore, that earthquakes and volcanos cannot be the cause of the production of epidemic diseases, we must conclude, if there be any relation or connection between these different phenomena, that they are common effects of a common cause.

---

* *Commentaries,* vol. xvi. p. 36.

But then it may be argued, that as epidemic diseases sometimes extend over countries and districts in which neither the shock of the earthquake nor eruptions of volcanos are observed; while, in other situations, the interval between the appearance of the malady and the occurrence of these phenomena is frequently considerable, we can have no direct proof of the existence of volcanic action in every situation visited by these diseases.

This argument might have some weight, if we confined our ideas of volcanic action entirely to the eruption of the volcano, and the shock of the earthquake, or considered that these are the only phenomena cognizable by man of the existence of this process in the interior of the globe. But these phenomena, it should be remembered, are only local, and, frequently, accidental effects of the operation of this cause on the crust of the globe. With respect to the first, or, the volcanic eruption, it is generally admitted, that the sudden expulsion of lava from the interior to the exterior is due to the expansive force of steam—produced by the precipitation of water on the melted matter contained in volcanic foci. This conclusion appears to be confirmed by the well known fact, that all volcanos are found near to the sea, or great inland collections of water. It is, also, to be borne in mind, that the fissure or volcanic vent is generally formed in secondary strata composed of rocks, which, by their solidity and texture, may be supposed to offer a great and effectual resistance to the escape of pent up aqueous or other elastic matter. Hence we may conclude, that the formation of a volcanic vent is due to the accidental and sudden contact of water on an intensely heated surface, and the consequent generation of a large quantity of steam, which, unable to find an outlet, rends asunder by its expansive power the superincumbent strata; ejecting at the same time, not only the pent up gazeous matter, but a portion, also, of the incandescent, or melted lava.

If, therefore, the propulsion of lava through the duct of a volcano be caused by the explosive force of steam, we may infer, that, before it can overcome this immense weight, the hydrostatic pressure exerted on the sides and roofs of the cavities will be such as to occasion, not only slight tremors, but, also, violent concussions of the crust of the globe. Hence the occurrence of earthquakes not only at the time, but, also, before the formation of a volcanic vent.

As, however, the ejection of lava from the interior to the surface is due entirely to the accidental presence of steam, we must allow, that at other times or in other situations, where the same action is going on, this phenomenon cannot be witnessed, from the absence of those contingent circumstances necessary for its production. These are the existence of melted matter, in order to convert the water into steam; its generation, in sufficient quantity to overcome the weight of the superincumbent strata; and its confinement within certain boundaries, so as to be able to exert a hydrostatic pressure sufficient to produce a volcanic vent, and the propulsion of the pent up matter. Such being the case, we cannot be surprised to find, that volcanic eruptions take place so seldom, even in situations where earthquakes are frequent and common; for the power, that is insufficient to rend asunder the crust of the globe, may, nevertheless, be adequate to produce, not only slight tremors, but even violent concussions. As, also, a combination of the same circumstances, although less in degree, would seem to be necessary for the production of the earthquake, we must also infer, that at other times, and in other situations, even this effect cannot take place; although the process itself, whatever that may be, which is known by the term volcanic action, is in existence at the time. Thus, if water does not percolate at all to the reservoirs of melted matter, or only in small quantities, no concussion can be felt; if we allow, that earthquakes are produced by the same cause as that, which gives rise to the volcanic eruption—a conclusion, which we are bound to admit in the present day; for we may, as Lyell truly remarks, regard earthquakes as abortive volcanic eruptions.

Granting, however, that the shocks sometimes felt on the surface of the earth are produced, not by the expansive power of steam, but, as some geologists would have us believe, by the condensation of other and permanently elastic gases, the product of the volcanic process, still, it is evident, that even then this phenomenon can only be produced under particular circumstances; for, unless gazeous matter be evolved in sufficient quantity, and unless it be confined for a sufficient length of time to produce the necessary condensation, no concussion would be felt.

But, then, it would be most unphilosophical to suppose, because we have none of those great catastrophes, which proclaim the operation of this cause on the crust of the globe, that the action productive of them is dormant, either during the interval of their occurrence, or in situations where these phenomena are not observed at all. On the contrary, we have proof, that this action does not cease with the subsidence of the above effects; as many circumstances could be mentioned, which show, that volcanic foci retain their intense heat for ages. Nor can we suppose it to be otherwise; for if, as Lyell most justly remarks, lava currents of moderate thickness require many ages to cool down in the open air, we must conclude, that the great reservoirs of melted matter, at vast depths in the nether regions, preserve their high temperature and fluidity for thousands of years. We may, therefore, assume, with a writer in the *Encyclopædia Metropolitana*, "that the eruptions of burning mountains are only the external manifestations of a cause generally diffused throughout nature; and that the minor indications of the same may, therefore, be looked for, when these mightier ones are unknown."* This is confirmed by numerous phenomena; for, as another authority states, "Perennial supplies of hot vapour and aëriform fluids rise to certain craters, which are in a state of ceaseless eruption. Numerous solfataras, evolving the same gazes as volcanos, serve as permanent vents of heat generated in the subterranean regions. The plentiful evolution, also, of carbonic acid from springs and fissures, throughout hundreds of square leagues, is another regular source of communication between the interior and the surface. Steam, also, often above the boiling temperature is emitted for ages, without intermission from 'stufas,' as the Italians call them. Even silex, carbonate of lime, muriate of soda, and many earths, alkalies, and metals, are poured out in a state of solution by springs, and the solid matter, which is thus tranquilly removed in this manner, may, perhaps, exceed that, which issues in the shape of lava."† In fact, it is probable, as the above author suggests, that to the efficacy of this ceaseless discharge of heat and of solid, as well as gazeous matter, we owe the comparative tranquillity of our globe. But it is principally in the neighbourhood of extinct volcanos, or in situations, where earthquakes have been frequent, and chasms formed, that these phenomena are observed. Although, therefore, their continuance for long periods shows, that volcanic action may go on in the interior of the globe for ages, without any eruption, or earthquake, we can derive no evidence from this source in proof of our proposition; for epidemic diseases prevail at all periods, and anterior to the formation of vents and chasms, as well as in situations, where these effects are not witnessed.

---

* *Art. Geology.*

† *Lyell.*

There are, however, fortunately for the object of the present inquiry, other and more general signs of the existence of this process—phenomena which not only occur at the same time with the former, but previously to the eruption and the earthquake. Such are "irregularities in the seasons; sudden gusts of wind, interrupted by dead calms; violent rains in countries, or at seasons, when such phenomena are unusual or unknown; a reddening of the sun's disk, and a haziness in the air, often continued for months; an evolution of electric matter, or inflammable gas from the soil, with sulphurous and mephitic vapours, etc."*

These phenomena have been generally observed in the neighbourhood of active volcanos, and immediately preceding or subsequent to some particular eruption. But the same phenomena, and particularly the changes in the dryness or moisture of the climate, although less in degree, have been remarked in all countries subject to volcanic eruptions and earthquakes, not only at the moment when these effects take place, but for some time previous and subsequent to their occurrence. So apparent, indeed, is the connection, at particular periods, and under particular circumstances, between atmospherical phenomena and terrestrial concussions, and so generally is the one set accompanied by the other, that it was long supposed the changes in the electrical states of the atmosphere were the cause of the concussions. Even now there are writers who contend, that earthquakes are produced from this cause, or from electricity. But, as Mitchell truly remarked, long since, it is more probable that the air should be influenced by the earthquakes, than that the earth should be affected in so extraordinary a manner, and to so great a depth, by a cause residing in the air.

---

* *Lyell.*

The truth of this conclusion has been well ascertained in the present day, with respect to those atmospherical phenomena, which occur at the time of the eruption of the volcano, and the shock of the earthquake; but it is not supposed, or even hinted at, by any one, as far as I am aware, that the same effects, which are observed at other times, and in other situations, when the more direct evidence of volcanic agency is wanting, are also due to the operation of the same cause. That such is the case, we might infer, from the good old analogical mode of philosophizing, that like effects must proceed from like causes—more particularly when we call to mind the atmospherical vicissitudes, that are observed in every latitude at particular times,—variations which cannot be referred to difference of climate, temperature, electricity, moisture, or dryness of the atmosphere, as all attempts to trace the cause of those atmospherical changes, which occur at irregular periods, to these sources, have hitherto failed. Another and a different theory, therefore, would seem to be required, in order to elucidate this important, but obscure, subject. As such, we will briefly consider what the atmospherical phenomena are, which have been observed at the periods of volcanic eruptions, the order of their appearance, and their duration; and then endeavour to ascertain, if the vicissitudes observed at other times, even in situations or countries not known to be volcanic, are characterized by the same peculiarities; and if they appear to be governed by the same laws. If so, we may fairly conclude, that the cause productive of these effects is the same in both instances; although no other and more direct evidence is afforded at the time.

Now the phenomenon that is first observed, and which may be relied on as indicative of the existence or commencement of volcanic action, is an increase of heat on the surface of the earth, which is productive of great and unusual droughts as well as a dry and hot atmosphere, altogether unusual to the situation, the climate, or the time of year. That such is the case, in the immediate neighbourhood of the volcano, there can be no doubt, for the history of every eruption, with which we are acquainted, incontestably proves this fact. When, however, this phenomenon has been observed in other situations far removed from the site of any active volcano, it has seldom been supposed, that the cause of its production was the same in this case as in the former. The relation, however, between terrestrial heat in general and volcanic action has not escaped the observation of Webster; for he remarks: " An evidence of the effects of fire or electricity* on the earth and air, before its explosion, is *the extreme drought* which is so often experienced over whole continents, or the whole world, for 6, and even 12 months, *antecedent to a great eruption of volcanos.*" Many instances, adds this writer, have been related: it is sufficient here to mention *the excessive drought* in 1762 and 1782, *preceding eruptions* of Ætna and Heckla. In these years almost all springs were exhausted, *not only on the continent of Europe*, but, also, over *a great portion of America.*

As, on the one hand, a partial or complete failure in the water supplied by land springs, or great droughts, are usually experienced immediately antecedent to the eruption of the volcano; so, it seems probable, that the dry seasons which are frequently experienced over considerable portions of the globe, should also be ascribed to the same cause. Webster states that such seasons never occur, except during the approach of comets, or antecedent to volcanic eruptions. Thus, a dry season, in 1782, preceded the great and memorable eruption of Heckla in 1783, and unusually dry seasons, both on the continent of Europe and in America, have generally been observed previous to eruptions of Ætna and Vesuvius. For the want of historical data we are unable now to say what were the limits or boundaries of the effects referred to, in these particular instances; but it must be familiar to most persons, that while drought and hot and dry summers are experienced in one country, the reverse is observed in others—and this, too, even in contiguous countries. Thus, in the year 1816, when the middle of Europe was suffering from excessive wet, the north, for a time, and to a certain extent, was parched with drought; and public prayers appear to have been ordered, about the same time, at Dantzic and Riga, for rain, and at Paris, for sunshine.

---

* Webster laboured under the erroneous idea that all the phenomena ascribed to volcanic action are the effects of electricity—an opinion now generally abandoned.

But as great droughts and hot seasons generally precede volcanic eruptions and earthquakes, so, on the other hand, they are followed by heavy and long-continued falls of rain, accompanied by floods and inundations. With respect to the floods, which occur at the time of the eruption of the volcano, the cause is sometimes sufficiently apparent, for they are often produced by the flow of an immense body of water, from the mouth of the crater, which spreads itself over the plains, sweeping before it the inhabitants, their cattle, and their houses. The effect of these overflowings is frequently more destructive, and more to be dreaded by man, than the discharge of melted matter, however fatal and injurious such eruptions have sometimes been.

But, independent of the discharge of water from the duct of a volcano, there is, also, an apparent escape of water from the interior, by other channels, not only at the same time, but even when lava is alone given out from the volcano. Thus, during volcanic eruptions new springs are seen to burst forth, the water of old ones often becomes muddy, and their contents overflow, or are discharged with violence, and in considerable quantities. Independent of this effect, the water in the neighbouring rivers, or lakes, is found to rise suddenly above its level, and to overflow its natural boundaries—phenomena which are, doubtless, produced by the great and sudden discharge of the contents of those springs which, we know, abound more plentifully beneath the waters of the ocean, rivers, and lakes, than on the dry land. This effect may sometimes be produced by the formation of a rent, or fissure, as was the case in the earthquake at Oporto;

when the river, we are told, opened, and disclosed a chasm, from which immense quantities of water were spouted up.

But, in other instances, there is a sudden rise in the water of lakes and rivers in situations where no concussion has been felt. The phenomenon cannot, therefore, be referred in such instances to the formation of a rent, or fissure, and the discharge of water from volcanic foci; nor yet from the elevation of the strata beneath. Besides, these effects are generally observed in situations far removed from the spot, where the concussion was felt; so that we are assured they are produced by the discharge of water through natural channels, and not accidental chasms.

That during the eruption of the volcano, and, more particularly, at the time of the earthquake, the water of springs far removed from the centre of the concussion is frequently affected in an extraordinary degree, has been already mentioned in a preceding part of this paper, while detailing the phenomena witnessed in different countries during an earthquake at Lisbon. In addition to the examples then given I may mention, that even as far as Bohemia the mineral springs, which supply the warm baths, suddenly rose, and filled the baths in the course of a few minutes. This was on the morning of the concussion, and at the same time that the water in the different ponds, canals, and springs was agitated, and overflowed in other countries, nearer the seat of the concussion. The immediate cause of the phenomenon is, probably, this,—

We have seen, that during the eruption of the volcano, an immense quantity of aqueous vapour is given out from the crater; the effect, as we have before presumed, of the precipitation of water on the melted matter in volcanic reservoirs. If, therefore, we allow, as we are bound to do, that these reservoirs extend over considerable portions of the terrestrial sphere, and in situations far removed from any active volcano, we have only to suppose, that steam is generated beneath the surface, in those particular localities, from some accidental circumstance, in order to account for the production of the above phenomena, even in districts not known to be volcanic; for if neither rents nor chasms have been formed on the surface, the inference is, that the elastic vapour would endeavour to escape by those natural outlets, which exist, to a greater or less extent, over the whole globe, and from which, as we have seen, both gazeous and solid matter is so constantly given out from the bowels of the earth.

If these deductions be correct, we may not only understand why floods and inundations are experienced at times, when it is impossible to account for their production by any unusual or excessive fall of rain; but, also, why they are observed in situations, where no other sign of volcanic action is in existence at the time—for they are more likely to occur in spots, where vents do not exist, and where chasms have not been formed.

The next phenomena which deserve consideration are the heavy falls of rain, which are sometimes experienced either at an unusual time of the year, or, if at the regular season, to an extent unknown at other times.

Now, the eruption of the volcano, which, it has been stated, almost invariably occurs in the midst of serene and settled weather, is as invariably followed by deluges of rain, and to such an extent that the surrounding country is frequently entirely flooded. This effect may sometimes be due to the immense volumes of aqueous vapour, which we know are evolved from a crater during eruptions, and, often, for a long time subsequently to the discharge of scoriæ and lava. "These vapours," says Lyell, "are condensed in the cold atmosphere surrounding the high volcanic peak; and heavy rains are caused, sometimes, even in countries, where under other circumstances such a phenomenon is entirely unknown." But we also witness the same occurrence, when no vapour is given out from volcanic vents, and also after earthquakes—when from the absence of chasms, or rents on the surface, the same means for the escape of aqueous vapour from the interior to the exterior do not exist. It is probable, therefore, that the effect referred to in such cases is to be ascribed, if we adopt the theory of some writers with respect to the formation of rain, to an alteration in the electrical state of the air—produced by the evolution of some gazeous substance from volcanic foci; or, if we adopt that proposed by Dr. Hutton, to the escape of caloric, either alone, or combined with aqueous vapour; and which, as we shall attempt to show presently, would be adequate to the purpose. But, whatever explanation may be given, as to the cause of this phenomenon, the fact remains the same; for, whenever satisfactory evidence is afforded of the existence of volcanic action, as known by the eruption of the volcano and the shock of the earthquake, there, also, we have proof, that these phenomena are invariably followed by a change in the climate, productive of heavy falls of rain, floods, and inundations.

The same changes and vicissitudes, however, as was before remarked, are also witnessed in situations where no evidence exists of the operation of this cause on that particular part of the crust of the globe, where they occur; for, although volcanic action extends in different directions over vast portions of the terrestrial sphere, still there are spots, where no volcano exists, and where concussions have either never been felt at all, or only at some long antecedent period.

The question, therefore, now is, are the falls of rain, which occur in these situations at irregular periods, due to the same causes as those, which produce the phenomenon in general; or, are they to be ascribed to the agency of some other and different cause? That the latter is the case, we might infer from the fact, that no theory hitherto proposed, with respect to the formation and descent of rain, will account for those sudden and unusual aberrations, that are experienced in certain situations, at particular periods — although that proposed by Dr. Hutton does account for certain anomalies, that are sometimes observed in the formation and descent of rain.* As to the *immediate* cause of the production of rain, this can only be ascribed to the condensation of the vapour, which constantly exists, to a greater or less extent, in the atmosphere; for it is a law of nature, now absolutely demonstrated, that water has a tendency to assume the elastic form, *at all temperatures*, however low.† There is not, therefore, a particle of air, either in the torrid zone or the frozen regions of the north, free from its given proportion of aqueous vapour. As, also, the vapour, thus diffused in the atmosphere, is derived from the waters, that cover so large a portion of the globe, this evaporation is constantly going on, to a greater or less extent, in all situations, and in all climates, not only at the equator, but at the pole. Such being the case, we might suppose, that an undue accumulation of moisture would take place in the atmosphere, on the one hand; or that the store would, on the other, become exhausted in time. "But, as this evaporation is due entirely to the active agency of heat, nature has fixed limits, beyond which it cannot pass; for, as the temperature on the surface of the earth, whatever may be its capricious changes, is confined in every climate within definite bounds, — so the minimum temperature of any period, whether it be that of a day, a month, or a year, must set a limit to the accession of watery vapour in the air; and thus, in every region, the equatorial, the temperate, and the polar, a strong and impassable barrier has been fixed by nature to the continued accumulation of moisture in the air.* As, also, this heat is retained within certain limits, and is differently distributed on the surface of the earth, it follows, that the rising moisture is compelled to distribute itself throughout the different regions of the great aërial volume according to well-known and fixed laws; for as there is a gradation of heat from the equator to the poles, so a given volume of air will contain less and less moisture, as we leave the equator and approach the poles.

---

* *Notice of Dr. Hutton's Theory.*

† *Enc. Metr., Art. Met.*

It is clear, therefore, if these deductions be correct, that not only will a certain quantity of vapour be present in the atmosphere at all times, but, also, that the proportion contained in a given quantity of air will vary in different regions—being greatest in the equatorial, and least in the polar regions. If, therefore, any circumstance should produce a condensation of the atmospheric vapour, either in consequence of the accidental withdrawal of the sun's rays, or from the natural changes in the seasons, so as to cause its descent on the surface of the earth, we should expect to find that the greatest quantity that fell would be near the equator, and the least near the pole. That this is the case, in general, there can be no doubt; for, as one writer justly observes, amidst the seeming diversities, which characterize the descent of rain, and which impress on particular localities, qualities, which seem to set all investigations at nought, we may yet conclude, that the maximum descent of rain will be found in the equatorial regions; and, at the same time, a diminution in its quantity from those regions to the poles.* If, therefore, this rule were found to be invariably the case, and if the fall of rain in all climates was only observed on the supervention of cold weather, or after a sudden diminution of temperature in the surrounding atmosphere, the theory as to the formation of rain would be simple enough; for the evaporation produced by the heats of summer, and the condensation caused by the cold of winter, and the vicissitudes in the temperature which occur at all periods, would account for the phenomenon. But there are certain anomalies of a very marked character, which present themselves to our notice, and which cannot be explained by a reference to the above causes alone; for a greater quantity of rain is found in one situation than another, although both happen to be in the same terrestrial parallel, or latitude; while, also, it frequently happens, that a fall of rain is observed at unusual periods, and when the condensation of the atmospheric vapour cannot be accounted for by any general diminution of temperature. Some of these anomalies have been accounted for in two different ways.

---

* *Enc. Metr. loc. cit.*

---

* *Enc. Metr. loc. cit.*

In the first place, it has been proved, that the evaporation on the surface of the globe is not the same in every latitude, or where the temperature is equal. Thus, the Mediterranean Sea, surrounded on all sides by land, is more heated than the ocean; while the winds, which blow over it, being drier, there is a more copious evaporation than in the Atlantic itself. This increased evaporation must therefore produce, at some subsequent period, and in a certain portion of the globe, a greater condensation and fall of rain than what is witnessed in other situations in the same parallel. Again: With the same average temperature throughout all the months of the year, the different currents in the air will at once introduce diversities of a very considerable kind. Thus, the annual evaporation at Whydah has been estimated at 64 inches; but, when the harmattan blows, the rate is augmented to 133 inches. This circumstance therefore would again produce, in that particular locality, a greater fall of rain than what is observed in other situations, where the temperature is the same.

In the next place, it has been found, as we have before remarked, that rain frequently falls, either in quantities greater than can be accounted for by the previous evaporation from the surface, or else, at unusual periods of the year; and when from the temperature we might infer, that evaporation, and not condensation, would be produced. To meet this, and certain other anomalies, Dr. Hutton proposed a theory, which differed from those of all preceding writers. According to this philosopher, rain results from the mingling together of great beds of air of unequal temperatures, and unequally stored with moisture—an opinion that has since been adopted by Leslie, Dalton, and other distinguished individuals. By this theory we are able to account for the production of rain in situations, and at times, when no elucidation is afforded by a diminution in the general temperature existing above the surface: as the only conditions necessary for the formation of rain, according to the above theory, are the accidental contact of certain portions of air differently charged with moisture, and of unequal temperatures; conditions, which must constantly exist, to a greater or less extent, over the whole globe, and during all seasons; for neither caloric nor vapour can be immediately, and, at once, equally and uniformly diffused through the whole body of the atmosphere. One portion of air, therefore, which contains a given quantity of caloric and moisture, will, when brought into contact with another portion, differently charged, cause, according to this theory, precipitation; or, in other words, a fall of rain. By this theory, we are not only enabled to account for the occasional showers, which are experienced in all climates, independent of the periodical fall of rain at particular seasons, but we can also explain certain anomalies, which are observed in particular situations, and at particular times.

Thus, the great atmospheric currents, produced by the trade winds, cause periodical descents of rain, which differ from those in other regions. The sea and land breezes, also, in tropical climates, by the blending together of opposite currents, produce, either daily, or at particular seasons, the phenomenon of rain. As, also, the heat of the sun, which produces a greater abundance of rain in certain regions, situated near to the sea, or large masses of water, which afford a great evaporating surface, becomes the cause of drought in situations farther removed from the sources, whence the moisture is supplied; so, on the other hand, there is sometimes an absence of all precipitation, even when currents of air, differently charged with caloric and moisture, are mingled together. Thus, there are certain situations where it seldom or never rains; as in the sahara of Africa, the low coasts of Egypt, and a portion of the coast of Peru. But then a particular wind prevails in these situations; and, as a wind constantly uniform, or nearly so, must, according to the theory of Dr. Hutton, either produce constant precipitation, or no rain at all, it follows, that the permanency of the wind in these situations insures the permanency of the result. Thus, it is the south-west wind which prevails constantly at Peru; and, as it passes from a colder into a warmer region, its capacity for moisture becomes increased, and hence there is no precipitation. The same cause will also account for the occurrence of rain in the constant trade winds; while we may also add, that dry weather is usually accompanied by a steady and uniform direction of the wind in most climates, at the same time that the winds are unsteady and variable in rainy weather.* But these aberrations, although exceptions to the general rule, as regards the diffusion of vapour in the atmosphere, and its subsequent condensation and fall, are yet, it will be observed, to a certain extent, uniform in their result: for, either they are felt constantly in particular situations; or else their occurrence, when experienced, can be ascribed to certain fixed principles. Thus, although the quantity of rain, which falls in one situation, is greater than in another, in the same latitude, and at a season of the year when the temperature is equal; still the annual average fall of rain in any particular locality will be found nearly uniform, and not to vary to any great extent, from the operation of the above causes alone: for we know, that the temperature, and the direction and force of the currents of air, or winds, do not vary, to any great extent, in different years.

---

* *Enc. Metr. Art. Meteorology.*

But there are certain other changes and vicissitudes, which cannot be explained by a reference to the above theory, more than to any other; for the aberrations are so great, that it is impossible to refer their production either to increased evaporation, on the one hand, or, on the other, to a great and unusual mixture of the different strata of the atmosphere; for the temperature is not sensibly increased; while the falls of rain frequently occur in the midst of very calm and settled weather. Thus, we find, from a series of observations that were made on the Malabar coast, from 1810 to 1823, that there was a deviation of more than 75 inches of rain, between the result of two years, at a time, when the difference of the mean temperature of the same years did not amount to a single degree. We have also stated, that, as a general rule, the quantity of rain, which falls in inter-tropical countries, is much greater than what is observed in extra-tropical ones. Thus, the mean annual amount of rain on the Malabar coast, is, it has been calculated, about 123 inches —while, in England, it only amounts to 31 inches; and at St. Petersburgh, to 16. But this proportion is frequently reversed; so that we have a greater fall of rain in a high northern latitude than what is observed in countries near the equator. Many instances have been adduced of excessive rains, for the parallels on which they fall; but the most extraordinary are those, which occurred on the continent of Europe, in 1827, and which are recorded in the 36th volume of the *Annales de Chemie.* Independent of places, where rain, less in amount, was noted to have fallen in unusual quantities, it was found, that at Joyeuse, on the 9th of October, 1827, there descended in the space of 22 hours only the enormous amount of 31 inches—being as much as what is usually observed in the same parallels during the whole year. The greatest diurnal amount, that had been observed in this place during a period of 23 years, was 9 inches; and even this was considered at the time an enormous quantity. There also descended in the space of 11 days at the same place and in the same month 38 inches of rain—a quantity double that which usually falls at Paris in the space of a year.

Again: In other situations we find, that, instead of the above aberrations, or an excessive fall for a short period, or during some particular year, there is a gradual increase for a long series of years, at the same time that the climate, or temperature, and all other external circumstances remain, apparently, as before. It has been satisfactorily ascertained, that the quantity of rain, which falls annually at Paris, has not varied in any sensible degree for 130 years; but it appears, from the results of a series of observations made at Milan, that the rain has been constantly augmenting from 1764 to 1816, the period during which the observations were made.

Now these are anomalies, which can never be explained by any theory hitherto proposed; although that of Dr. Hutton's does account, not only for the general formation and descent of rain over the whole globe, but also for certain other anomalies, or exceptions to the general rule. Such being the case, we are not only bound to conclude, that the above theory, when applied to the general formation and descent of rain, is a correct one; but, also, that the cause of the changes and vicissitudes, now referred to, must be different from that usually concerned in the formation and distribution of rain over the general surface of the globe. That this cause is the same as that, which gives rise to the production of the same effect in volcanic districts, we might *à priori* infer, when we observe, that the usual causes, assigned for its production in the generality of cases, are insufficient to account for the phenomenon in the instances under consideration.

We are strengthened in this conclusion by the fact, that the aberrations of rain in these particular instances are peculiarly characteristic of volcanic action; for, if we peruse the accounts, that have been transmitted to us, of those periods remarkable for excessive or unusual falls of rain, we shall find, that there is the same order, or progressiveness, in their appearance, as with other and well-known effects of volcanic action. Thus, periods of great rain have usually been preceded by droughts, or hot and dry seasons; the same as we have before remarked takes place in volcanic districts at the time of the eruption of volcanos. In addition to the above we shall find, that the rain, in these instances, is confined either to particular localities, or certain portions of the terrestrial sphere: the same as we have attempted to show is the case with volcanic action itself. Thus, rain is frequently found to extend a considerable distance, in some particular direction, at the same time that the *width of its range* is very limited; for we are able in numerous cases to trace the boundaries of considerable falls of rain, as well as the limits of particular and slighter showers. Now it would seem difficult to imagine, how any cause, existing above the surface, could be thus limited in its operation; especially if we refer the variation in these instances to a change of temperature in the atmosphere; for the operation of such an agent would be more general. Besides this, we have stated, that there is frequently no perceptible variation in the temperature of the atmosphere, at these particular periods; at the same time that unusual winds and currents of air are entirely wanting. Nor, on the other hand, can we ascribe the production of these effects to the mingling together of different currents of air, differently charged with heat and moisture, as the operation of such a cause must be too partial, and would never account for the extent of certain falls of rain; except in portions of the globe, where the trade winds blow; or at times when a regular and unvarying wind prevails in some particular direction.

We are thus furnished with a variety of proofs in support of the argument now advanced; for, if the causes, usually assigned for the formation and descent of rain, are insufficient to explain its production in the instances under consideration; and if, in addition, volcanic agency is found, at other times, to produce this particular effect, while the phenomenon itself appears to obey laws characteristic of this action, we can hardly fail to infer, that to the operation of this cause is to be ascribed the production of rain in the one case as well as in the other.

That there is another and a different cause in operation, in the instances that have been considered, we may also conclude from those great and sudden vicissitudes in the air, which are productive of snow, or hail at one time, and storms and hurricanes at another. In fact these phenomena illustrate the remarks, that have been made with respect to rain, much better, and in a more satisfactory manner, than the former as they are exhibited on a grander scale; while, as they offer so great a difference to the usual state of the atmosphere, the extent and limits of the variation are better observed; and can be more accurately defined.

That snow and hail should be produced by the agency of fire, or volcanic action, appears somewhat paradoxical upon a first consideration of the question; but it will cease to be so, if we conclude, that hail is produced in the same manner as rain, viz., by the mixing together of certain atmospherical strata, of unequal temperatures; and that the difference in the product is merely an effect of the greater difference in the temperature and moisture of the bodies of air, then brought into accidental contact. That hail is produced from the same cause as rain, we may conclude from the fact, that hail frequently precedes storms of rain, and sometimes accompanies them, as Arago has already remarked. It is probable, therefore, that they have a common origin; and that the difference observed is merely an effect of the difference of temperature in that part of the atmosphere, where they are formed—the same as we observe rain at one season of the year in particular countries, and snow and hail at another.

That the effects, now referred to, do not proceed from any *general cause* existing in the atmosphere, as decrease of temperature, or an undue accumulation of aqueous vapour in the upper and colder regions, and its condensation there, seems proved by the fact, that the clouds from which hail descends are generally situated very low. Thus, M. Arago mentions, that he has more than once seen clouds, from which hail would in a few minutes later have escaped abundantly, cover, as with a thick veil, the whole extent of a valley; whilst the neighbouring hills enjoyed, at the very same time, a pure sky and an agreeable temperature. Von Buch also remarks, that it very rarely hails on mountains in the temperate climates of the earth; and this he attributed to the low elevation of the clouds, from which hail descends.

If, therefore, hail be produced principally, or only, in the lower strata of the atmosphere, we are again led to look into the interior of the globe for an elucidation of the phenomenon; as we know of no cause existing on the surface of the earth, which could produce this effect, any more than we can understand, why those general causes, which influence the temperature of the surrounding air, should be thus partial in their operation.*

That the process, which is constantly going on in the interior of the globe, is sufficient for the purpose, we have proof from the phenomena, which are sometimes witnessed in volcanic districts. Thus, we frequently hear of hail and falls of snow after the eruptions of volcanos, even in the hottest countries, or during the middle of summer in colder climates. That in such instances these effects are to be ascribed to the same cause as that, which produces the discharge of melted matter, it is unnecessary to attempt to prove on the present occasion; for the connection between these different phenomena is too apparent to admit of any doubt. But it will not perhaps be so readily granted, that the same cause is productive of the same effects in all other situations where they are observed; or, at least, when they occur at irregular periods, or to an unusual extent in the accustomed seasons. That such is the case, however, we may conclude from the remarkable circumstance, that in such instances the formation of the hail is frequently confined to particular spots, of limited extent, and defined boundaries. The cause, therefore, must be local, and not general; or, in other words, the decreased temperature, which takes place in that portion of the air, where the hail is formed, cannot be ascribed to the abstraction of the sun's rays; for such an effect could not be thus limited in its operation. Independent of the above, it will be found that the falls of snow, or hail, which are observed at other times, *run in veins*, or along particular lines of the earth's surface, so that, although the width of their range is very limited, they yet extend *in a linear direction* over considerable portions of the terrestrial sphere. Now, this circumstance is in my opinion one of the most certain signs of volcanic action; for we have endeavoured to prove, that the operation of this cause invariably takes place along particular lines of the earth's surface.

---

* These anomalies have always excited the attention of philosophers: among others, Volta; who regarded the formation of small flakes of ice—the kernels of future hail-stones—in the month of July, and during the hottest hours of the day, as one of the greatest paradoxes in meteorology.

It is, however, during the occurrence of hail storms, that this phenomenon is best observed; for it so happens that hail, and not snow, is generally produced at these irregular periods. By a reference to the facts, that have been recorded by different writers, we shall find, that, although the effects of such storms are felt over considerable tracts, their lateral boundaries are very narrow; and so defined, that it is easy to ascertain the extent of their range. That such is the case, may be gathered from the tremendous storm, which desolated so great a portion of France in July 1788. "It began in the south, and proceeded in two parallel bands from the south-west to the north-east; the extent of one of them being 175 leagues, and of the other 200: thus traversing nearly the whole length of that great kingdom, and even a portion of the low countries. The mean breadth of the eastern band was four leagues, and of the western, two; and what is very remarkable, the interval between the two bands, amounting to five leagues, was deluged with heavy rain. Its progress from south to north was at the rate of 16 leagues an hour; and the continuance of the hail at each place, or town, was limited to 7 or 8 minutes." Another example of the definite extent of hail storms has been recorded by Mr. Neill, in the *Transactions of the Royal Society of Edinburgh.* In the storm which occurred in Orkney on the 24th of July 1818, a thick layer of hail, says this gentleman, formed a tolerably well defined belt across the island, in a direction from south or south-west to north-north-east. "It was about a mile broad, and so limited was its range, that persons, engaged in digging turf two miles to the westward of what appeared to be the very centre of the storm, were wholly exempted from its effects."

Independent of the above, we find, that hail storms are peculiar to certain situations, so that particular localities have been designated as hail countries; while no assignable cause, as difference of climate or temperature, can be given for this peculiarity. If so, and if we are unable to discover the cause above the surface, it cannot be unphilosophical to search in the interior of the globe, especially as we find a process there, which gives rise to the same effect at other periods, as during the eruption of volcanos.

There are, also, certain other phenomena, which, although they do not bear so immediately on the present subject (for it will be impossible to deduce the same arguments from this source as the others in support of the hypothesis now broached), may yet furnish additional proofs of the connection between atmospherical changes and volcanic processes. These are the occurrence of storms or hurricanes, which, in my opinion, afford strong proof that the cause which produces them is subterranean, and not atmospherical. My reasons for believing this are the same as those, which induce me to refer the phenomena, that have just been considered, to the same source, viz., that they are principally observed in particular situations, at the same time that they are confined to very narrow and well defined limits, or boundaries, and particular lines of the earth's surface. Thus, one country enjoys a comparatively calm and settled state of the weather; while another, in precisely the same latitude, and where the climate, temperature, and all other external circumstances are the same, is subject to violent hurricanes. This fact is well known to sailors, who are accus tomed to look out and prepare for storms in particular latitudes, but to repose with confidence and a feeling of security in others—and the experience of ages confirms their belief. Of these regions, the principal are the West Indies; the Mauritius; and the China Sea, where, alone, the severest hurricanes are experienced.

But not only may the whole globe be divided into two grand divisions—the dangerous and the secure—but it will also be found that these phenomena vary much in different situations; a circumstance which cannot be referred to mere difference of climate, or temperature, for the variation in this respect is too trifling to admit of any consideration. Thus the hurricane of the West Indies is different in kind and degree to that of the Mauritius, while the latter varies again from the Typhoon of the China Sea.

Since the above observations were first penned (for a paper containing, in a condensed form, the theory now proposed was translated into Spanish, and published in one of the medical journals of Madrid* during my residence in that capital), my attention has been directed to an able article in the *Edinburgh Review* for January 1839, being a critique on some works recently published on the statistics, or laws of storms and hurricanes. The reviewer prefaces his remarks by observing, "it is mortifying to the pride of science, and a reproach to every civilised government that we know so little of meteorology—of the laws and perturbations of that aëriel fluid, which exists within and around us—which constitutes the pabulum of life; and in which we should instantly perish, were it either polluted or scantily supplied. Considering the earth's atmosphere merely in its chemical and statical relations, our knowledge of its properties is at once extensive and profound. We have decomposed the gazeous mass into its elements, and ascertained their separate agencies in sustaining and destroying life — its weight, its variable density, its altitude, its action upon light, its electrical and magnetical phenomena, its varying temperature, whether we ascend from the earth, or move to different points on its surface, have all been investigated with an accuracy of result honorable to the industry and genius of philosophers. But, however great be the knowledge which we have acquired of our aëriel dominions, when in a state of serenity and peace, we must confess our utter ignorance of them in a state of tumult and excitement. But the last few years," continues this writer, " two or three individuals have devoted themselves to the study of the gales and hurricanes that desolate the tropical seas, with a zeal and success which the most sanguine could never have anticipated. They have not, indeed, yet succeeded in discovering *the origin* of these scourges of the ocean; but they have determined their general nature and character; and have thus been able to deduce infallible rules, if not to disarm their fury, at least to withdraw us from their power. Before the attention of philosophers was directed to the investigation of individual tempests and hurricanes, it was generally believed, that a gale differed from a breeze only in the velocity of the air which was put in motion. The first person who opposed himself to this vulgar error was the late Col. Capper, of the East India Company's service. After studying all the circumstances connected with the hurricanes which occurred at Pondicherry, in 1760 and 1773, this intelligent observer inferred that hurricanes were whirlwinds, whose diameter could not be more than 120 miles. Col. Capper also concluded that these whirlwinds had sometimes a progressive motion. These valuable observations seem to have excited no attention until Mr. C. Redfield was also led to the subject by independent observations. He concluded with Col. Capper, that the hurricanes of the West Indies, like those of the East, were great whirlwinds. He found, also, what had been merely hinted at by Col. Capper, that the whole of the revolving mass of atmosphere advanced with a progressive motion (the direction being on the coast of America from south-west to north-east). Thus one of the hurricanes described by Mr. Redfield commenced at St. Thomas's on the 12th August, and continuing its course by the Bahama Islands and the coast of Florida, then passed along the American shores, and terminated its devastations to the south of the island of St. Pierre, in lon. 57° west; and lat. 43° north. The second hurricane described by this gentleman commenced at Barbadoes, and passed over St. Lucia, St. Domingo and Cuba, and reached the northern shores of the Gulf of Mexico in about 30° of north lat. Here it seems to have been arrested by the mountains of Alleghani; but it, nevertheless, occasioned heavy rains over a large extent of country beyond this boundary."

---

* *Boletin de Medicina, Cirugia, etc.,* 20th Aug., 1835.

" The storms of the West Indies described by Col. Reid, like those which have been adduced by Mr. Redfield, form a sort of parabolic curve; and, what is peculiarly interesting as well as important, *they all pass over the same lines*, and all have their apex at the parallel of 30° lat., north. It also appears that there is, in all these instances, a central line along which the hurricane is most severe; while its effects gradually become less and less as it extends, on either side, of this particular line—Mr. Redfield stating, that, although the general width of the tract, more or less influenced by the hurricanes witnessed by him was from 500 to 600 miles, yet the severe effects of the storm were only felt over a width of about 150 to 250 miles." Now these circumstances are not only characteristic of volcanic action in general, but they are, also, peculiar to the atmospherical phenomena before referred to; for we have seen, that falls of rain in certain cases, and storms of hail, in general, are confined to very narrow boundaries, although they extend over considerable tracts in some particular direction.

In a late number of the *Philosophical Magazine* there are some observations of Mr. Martin, which show, in another point of view, the intimate connection, which appears to exist between hurricanes and storms of hail. This gentleman says, that there is only one way in which he supposes such masses of ice, as are sometimes formed, can be suspended long enough in the air to grow to such enormous sizes, and that is by the assistance of a nebular whirlwind; with sufficient power to keep them in its whirl, and to resist the earth's attraction, whilst the concretive action is going on; till their momentum overcomes the suspending power, or till they are thrown beyond the range of its intensity. This inference is, no doubt, a correct one, for we have already seen that hurricanes are only progressive whirlwinds: while we have before inferred that these and hail storms are produced by the same causes. But, independent of the above inference, Mr. Martin also states that he once saw a narrow column of dark vapour, which he could distinctly observe to be *in rapid rotary motion*, and passing from one cloud to the other.

Another law, characteristic of these phenomena, is their limited duration, not only generally, but, in each spot over which they pass. Thus, the rate of progress of the hurricanes described by the observers referred to, was from 15 to 20 miles an hour; and the duration of the most violent portion of the storm in each spot over which it passed, was from 7 to 12 hours. The same law is characteristic of hail storms, except that in these latter the rate of progress is greater and the period of their duration less—at least if we limit the duration of the storm to the descent of hail. Thus, the hail storm which occurred in France, and before described, did not continue in the different places which it visited more than 7 or 8 minutes, while the velocity of the two bands, which travelled on at the same rate, was about 16 leagues an hour. But we ought not to limit the duration of the storm to the period when the hail falls, for certain other phenomena peculiar to storms in general, and which properly mark their commencement and decline, continue for a longer period—the same as we observe the eruption of the volcano and earthquakes to be ushered in by certain signs, which, it may be observed, are all atmospherical. If, therefore, hurricanes obey the same laws, as other well-known effects of volcanic action; and if the latter, as we have attempted to show in another place, are usually accompanied by atmospherical changes and vicissitudes, we can hardly fail to conclude that they are produced by one and the same cause—particularly as no theory has yet been proposed which satisfactorily accounts for the production of storms and hurricanes.

But, independent of the inferences and deductions to be drawn from the above indirect proofs, there are other circumstances which would seem to afford additional evidence that volcanic action is in operation at these particular periods. Thus, storms are frequently ushered in by the same state of the air as that which usually precedes volcanic eruptions. This is an unusually calm and settled state of the atmosphere, which having been frequently observed, has probably given rise to the popular adage, that after a calm comes a storm. There also seems to be at these periods an evolution of electric matter; and which, as is well known, is a common result of the operation of volcanic action in the interior of the globe—for there is always a great discharge of electric matter during the eruption of volcanos and the shocks of earthquakes. Thus, in one of the Barbadoes hurricanes, as we are informed by Colonel Reid, a large portion of the trees in an extensive forest in this island *perished*, *without being blown down*—an effect that could only have been produced by electricity. There is also another phenomenon, which presents itself to our notice on these occasions, and which is common during the occurrence of terrestrial concussions. This is the appearance of a peculiar and singular cloud. Thus, in the Barbadoes hurricane of 1831, Mr. Simons of St. Vincent observed, *before the storm reached that island*, a cloud to the north of him, so threatening in its aspect, that, as he informed Col. Reid, he had never seen anything so alarming, during a residence of 40 years in the tropics. It was of an olive green colour. Mr. Simons hastened home, and, by nailing up his doors and windows, saved his house from the general calamity.

The same phenomenon has not only been observed at other times; but it is usually considered to be the harbinger of an earthquake, in those countries where the latter are frequent. Thus Dr. Stukely states, it has been generally remarked in the history of earthquakeas, that they begin in calm weather with a black cloud.* Again: the earthquake which occurred in Naples, in 1730, was accompanied by an atmosphere overcharged with *dense, low, immoveable clouds,* which shortly afterwards disappeared.

In addition to the above, there are certain other phenomena observed at the time of the occurrence of storms and hurricanes, which afford more direct evidence in support of our conclusion. In the first place, it appears certain that *earthquakes* have sometimes been felt *simultaneously* with the storm; for, in the hurricanes of 1780, two of the most tremendous visitations of physical power which have been let loose upon the globe, concussions were experienced. In the first of these instances, after the tempest had abated, the sea, as we are told, exhibited an awful scene; the waves swelled to an amazing height, rushed with indescribable impetuosity on the land, and overwhelmed the town of Savannah Le Mar. When the waters began to abate, *a most severe shock of an earthquake was experienced.* In the second, called the great hurricane, and which followed in about three weeks, Sir George Rodney stated, that nothing but an earthquake could have occasioned the foundations of the strongest buildings to be rent; and he therefore concluded, that the violence of the wind prevented the inhabitants from feeling *the earthquake which*, he was assured, *attended the storm.*

---

* *Phil. Trans., Vol.* 10, p. 110. *Ib., Vol.* 7, p. 46.

In the next place it will be seen, by a reference to any geological work, that the district described by Mr. Redfield and Col. Reid, and over which the hurricanes of the West Indies usually pass, is evidently volcanic; and, what is still more remarkable, the course pursued by these storms passes over the very track marked out by geologists as the lines and boundaries of the volcanic action in these regions. " The volcanic islands of the Antilles," observes one writer, " seem to be the links which connect the chain of primary mountains in the Caraccas with that, which runs across the islands of Porto Rico, St. Domingo, Jamaica, and Cuba; while the connection is evidently extended through the whole of the Leeward and Windward islands, which, with the above, form, as is well known, a regular crescent. The connection between these different volcanic islands, is evinced from the earthquakes, to which the non-volcanic chains above mentioned are so subject, ceasing upon the breaking out of an eruption in one of the volcanos of the neighbouring islands."*

Col. Reid has, also, with much labour and most praiseworthy zeal, traced the course and situation of the hurricanes of the southern hemisphere; and it is a remarkable fact, and confirmative of the statement now made, that the whole, viz. 13 in number, took place in the neighbourhood of volcanic districts. The greater number of these occurred near to the Mauritius and the Island of Madagascar, a well-known volcanic region; for there is an active volcano in the isle of Bourbon; while, in Madagascar, eruptions are recorded to have taken place, although we are not furnished with particulars as to their frequency, violence, and extent. Hence we see the truth of the opinion, which prevails among seamen, that hurricanes are frequently avoided by ships steering a course to the eastward of the Mauritius.

The exceptions to the above, referred to by Col. Reid, are the Albion's in 5° of south lat., and in 90° of west longitude; and the Bridgewater's and the Ganges, on the western coast of South America, near to Chili and Peru. Now it so happens that both these districts are volcanic, the former being to the westward of that remarkable chain before described, and which extends from Barren Island, through Java, Sumatra, and the Philippine Islands, etc.; while the latter situation is close to the line of volcanos, which it has been already stated extends from Cape Horn to California, and probably much further north. The hurricanes, or typhoons, of the China Sea have not been analysed by Col. Reid, which is unfortunate, as this sea is bounded on one side by the volcanic chain just referred to—the course and extent of which have been particularly described in a former part of this work. There are in fact few, if any, situations where volcanic action is going on to a greater extent, or where the boundaries are better defined. It would have been interesting, therefore, to have shown, by the same proofs as have been adduced in the former instances, that the course of these hurricanes is along, or parallel to, this volcanic line. That such will be found to be the case, I have little doubt; but as we have no proof on the subject, we must rest contented with the facts, that have been recorded respecting the hurricanes of the West Indies; for the other hurricanes described, although occurring in a volcanic district, cannot be proved to proceed along a well-known and visible line marked by volcanos, either active or extinct, as the vents must be situated beneath the waters of the ocean, where all evidence of this kind is necessarily wanting.

---

* *Rees' Cyclopædia.*

Sufficient, however, has been accomplished by the labours of these gentlemen to prove, in my humble opinion, not only that my previous conclusion was a correct one, viz. that hurricanes are principally observed in volcanic districts ; but also to show, as the result of the data they have collected, that these phenomena are confined to particular and well defined lines of the earth's surface. This proof is also the more valuable on account of its coming from disinterested witnesses; as these writers, in describing the situation in which the principal hurricanes have been experienced, are either ignorant that the tracks which they have marked out as the course of the storms are volcanic ; or, if aware of the fact, have not brought forward any arguments, or drawn any conclusion in consequence, as to the probable connection between these phenomena and volcanic action. When, however, we refer to certain geological works, and trace out the various volcanic lines which have been discovered, as extending in particular and different directions over the earth's surface; and when we turn to the accounts given by these meteorological investigators, and observe that the tracks over which the storms pass, as delineated on the maps affixed to their works, are not only similar in extent and width; but that, in addition, they are situated either in the immediate neighbourhood of well-known volcanic regions, or else embrace the very self same lines of the terrestrial sphere; we can hardly fail to infer that there must be some intimate connection between these atmospherical phenomena, and the process which we know is going on beneath the surface. Did it so happen, however, that the tracks thus marked out exhibited no direct proofs of the existence of this action beneath the surface; still we might, even then, deduce arguments in proof of this connection, from the facts that have been recorded, as to the progress, extent, duration and character of hurricanes ; for it would seem that they are governed by the same laws as the other effects of volcanic action, viz., their progression along particular and well defined lines, and their limitation to well marked and narrow boundaries. If, therefore, storms be due entirely to the operation of volcanic action, and if there be, as we have a right to infer, an evolution of electric or other matter from the interior to the exterior, at the time of their occurrence; we shall not only be able to arrive at a fair and rational elucidation of the immediate cause of the production of these phenomena; but we may also be enabled to explain many anomalies, which are observed at the time of their occurrence, and which are inexplicable by any other theory.

Now we know, that, whenever volcanic action is in existence in the interior of the globe, there is, either constantly, or at irregular and distant periods, an evolution of gazeous matter on the surface of the earth—and which escapes equally from the vents of volcanos; the chasms formed by earthquakes; and the mouths of springs. If, therefore, hurricanes be produced by the agency of volcanic action, we can only infer, that they are the effect of the sudden evolution of gazeous matter along the line or track, which they pursue. Not that I mean to affirm, that the wind produced in these instances, is simply the gazeous matter evolved from volcanic foci, but only that this evolution is *the cause* of the phenomenon, for it may be produced in two or three different ways.

In the first place we may presume, that, whenever aëriform matter escapes from volcanic foci, caloric is given out at the same time; as we know to be the case when gazeous substances are evolved from the vents of volcanos; the fissures formed by earthquakes; and the mouths of those springs that penetrate to the reservoirs of melted matter. It is clear therefore that, if aëriform matter, of a temperature higher than the surrounding atmosphere, be evolved at a particular point, or along a particular line of the earth's surface, a partial vacuum will be produced; the consequence of which must be the sudden rush into the vacant space of the colder air which surrounds it. The effects referred to, however, may be produced simply by the condensation of an immense quantity of gazeous matter in the subterranean reservoirs; and its escape, with a force and a power sufficient to overcome all resistance, through any chinks, or openings, whether natural or artificial, that may exist on the crust of the globe, immediately above the reservoirs. This inference seems confirmed by the nature of hurricanes, which, as we have stated, are now proved to be whirlwinds—the very effect that would be produced by the escape of air, or other gazeous matter, through small openings, or chinks; the same as when eddies or whirlpools are formed by the rush of water from a small pipe, or apperture into a reservoir.

But not only are we enabled to account for what would otherwise be inexplicable, by a reference to the causes known to be in operation above the surface, and which influence the production of ordinary winds, and currents of air; but we may also explain by the same theory, what otherwise appears to be a perfect anomaly, viz., that the force and direction of the wind is *contrary* to that which the hurricane takes. In fact, we should expect to find, if gazeous matter, either from increased condensation, or other cause, is escaping with force along a particular line of the earth's surface, that the rush of this matter into the atmosphere would be in a contrary direction to that which marks the escape of the pent up gas along the surface.

There is, also, another phenomenon, which admits of explanation by a reference to the operation of the same cause; and which has been particularly dwelt upon by Col. Reid, and the other observers. This is the fact, that the atmospherical cylinder, at first small, gradually enlarges in circumference, until at last it terminates, at the end of the line, in ordinary and casual winds; for the longer the gazeous matter continued to escape, the larger would be the circles produced by it—an effect readily observed in an aqueous body.

If these deductions be correct, we are bound to infer, that those grand phenomena of Nature, termed hurricanes, are produced by the operation of a cause, which exists in the interior of the globe; and is that usually designated volcanic action. Granting this, we derive another argument in proof of the theory that has now been given; for if the above phenomena are produced by this cause, we may reasonably infer that those atmospherical vicissitudes, which have been before considered, are so also—particularly as they obey the same laws, and are inexplicable by any other theory.

I shall therefore assume, for the moment, that this conclusion is a correct one, and pass on to the history of particular epidemics; in order to show, that at such periods atmospherical phenomena and terrestrial concussions prevail generally, and along the same lines, or portions of the globe, as the diseases themselves. For this purpose two diseases have been selected; viz., the black death of the 14th century, and the epidemic cholera,—the one remarkable in the history of such plagues, for the extent of its range, and the amount of its ravages, and the other as having occurred within our own time, and, therefore, interesting as well as important to the majority of persons; for the facts connected with the prevalence and progress of the cholera must be fresh in the recollection of all, while neither the disease, nor those phenomena which, as I infer, are connected with it, have yet entirely subsided.

CHAPTER II.

Commencing with the black death, we find that this disease, like most other plagues, first appeared in the east, and then slowly and gradually spread itself over Asia and Europe by a route, which has been already detailed; having broken out in China in the year 1333, just 15 years before its appearance in Europe. Unfortunately, we have no very exact accounts of the phenomena, which attended the first outbreak of the malady, nor of the number of times the disease reappeared, before it reached the confines of Asia. If, however, the statements, handed down to us by contemporary writers, are to be depended on, the irruptions of the disease in China must have been awful in the extreme, and the subsequent returns frequent and terrible, for we are assured that 5,000,000 perished in one year.

Simultaneously with the outbreak of the malady commenced a series of terrestrial commotions, almost unexampled in the history of such phenomena; for we find, that a few months after the severe visitation, just referred to, an earthquake occurred at and near Kingsai; and so severe was the concussion that the mountains of Ki-ming-chan fell in, and a lake was formed of more than a hundred leagues in circumference, where thousands we are told found their grave. These concussions continued to return in China, at short intervals, for many years; as we have it recorded that an earthquake, which continued ten days, occurred in Kingsai in 1338, and again in 1339, when the mountain Hon-tchang was swallowed up. From this time they became more and more frequent, until the year 1347, when they subsided altogether, or did not prevail to the same extent, for we have no further accounts of similar catastrophes. But, independent of the above, there are other phenomena, which deserve consideration on the present occasion; for if the deductions before made be correct, we are bound to conclude that certain atmospherical vicissitudes are also proofs of the connection, which I have attempted to show exists between epidemic diseases and volcanic action. We will, therefore, briefly inquire what phenomena of this kind were observed, during the march of the black death of the 14th century.

As was to have been expected no account has been transmitted to us of such phenomena previous to the commencement of the disease in China; but we find that, simultaneously with the outbreak of the malady in that country, a parching drought prevailed in the tract of country watered by the rivers Keang and Hoai. This was followed by such violent torrents of rain in and about Kingsai, at that time the capital of the empire, that, according to tradition, more than 400,000 people perished in the floods. In the succeeding year, an unexampled drought was felt in Tche; and in Kou-kouang and Ho-man a drought prevailed, accompanied by innumerable swarms of locusts, while famine and pestilence, as usual, followed in their train. From this time there was a constant succession of rain and floods in China; and in the year 1338, after three months rain in Pien-tcheou and Leang-tcheou there followed unheard of inundations which destroyed seven cities. Violent rains, with floods and inundations, continued to recur, and to devastate various districts until 1347; when, as we are informed, the fury of the elements subsided in China—being, it may be observed, about the same time as the cessation of the terrestrial concussions.

The disease then spread, in a westerly direction, across the continent of Asia to the shores of the Black Sea, committing the same devastations in the countries situated on this line of route as in China, for we are informed that India was nearly depopulated; while Tartary, the Tartar kingdom of Kaptschak, Mesopotamia, Syria, and Armenia, were covered with dead bodies. It was not until 1347 that the plague broke out in Constantinople, having previously ravaged, however, the districts between this city and the Black Sea; or, according to the general Byzantine designation, "the country of the Hyperborean Scythians!" It would also appear to have been as severe in this situation as in the former; for we learn from the same sources, that the countries between those then great routes of commerce—or Constantinople and the Black Sea—were nearly depopulated. Indeed, it was reported to Pope Clement, that throughout the east 23,000,000 were carried off; and this too, it is said, independent of the mortality in China. But this probably is an exaggeration; although, from the accounts handed down to us, it is certain, that the ravages of the disease were great beyond all calculation and belief.

Although there can be little or no doubt that the districts thus visited by the disease also experienced, to a greater or less extent, the same terrestrial commotions and atmospherical phenomena, which we know took place in China, we have no authentic records to refer to for proof of this opinion. We must, therefore, rest contented with the evidence to be derived on this point from other countries visited by the disease; and where, from the difference in their state of civilisation and learning the phenomena, that then occurred, were noted and recorded by the writers of that period.

The disease, on reaching the borders of Asia, did not appear to have lost much of its intensity and malignity; for we learn, that in Aleppo 500 died daily; while 22,000 people and most of the animals were carried off in Gaza within six weeks. Kairo, we are told, lost daily, when the plague was raging with its greatest violence, from 10 to 15,000; being as many as in modern times great plagues have carried off during their whole course.*

From Constantinople the epidemic, still continuing its westerly course, appeared as early as 1347 in Cyprus, Sicily, some of the sea ports in Italy, and also Marseilles; the remaining islands of the Mediterranean, particularly Sardinia, Corsica, and Majorca, having been visited in succession. "Foci of contagion existed also in full activity along the whole southern coast of Europe; when in January 1348 the plague appeared in Avignon, and in other cities in the south of France and north of Italy, as well as in Spain."†

Referring to the accounts transmitted to us of the intensity of the disease in this route, we find it recorded, that Cyprus, one of the first towns visited, was almost depopulated. Italy is said to have lost nearly half its inhabitants; and this account is rendered credible by the immense losses of individual cities and provinces. In Florence there died, as we are told, 60,000; in Venice, 100,000; and in Avignon the mortality was so great that the Pope found it necessary to consecrate the Rhone, that bodies might be thrown into the river without delay, as the church-yards would no longer hold them. In Sardinia and Corsica, according to the account of the distinguished Florentine, John Villano, who was himself carried off by the plague, scarcely a third part of the population remained alive; and it is related of the Venetians, that they engaged ships at a high rate, to retreat to the islands,—so that after the plague had carried off three-fourths of the inhabitants, that proud city was left forlorn and desolate. From Avignon the plague spread itself through France with the same virulence; for it is stated that in many places not more than *two in twenty* of the inhabitants remained alive.* At Marseilles, 16,000 died in the short space of a month. Many were struck, as if by lightning, and died on the spot; and this more frequently among the young and strong than the old. Flight from infected cities seldom availed the fearful; for the germ of the disease, to use the language of the historians, adhered to them; and they fell sick, remote from assistance, in the solitude of their country houses.

---

* *Hecker, On the Black Death of the* 14*th Century.* † *Ibid.*

The epidemic next appeared in England, and with the same fatality; for the sick, who were attacked with vomiting or spitting of blood, died in some cases immediately; in others, within twelve hours, or at the latest in two days.† It first broke out in the county of Dorset, and thence spread with unexampled rapidity through the counties of Devon and Somerset; and, after attacking Bristol and Gloucester, reached Oxford, and ultimately London.

---

* *Wood Historia et Antiquitates Universit. Oxon.*

† *Barnes Hist. of Edward III.*, p. 432.

From this the malady extended itself northwards; most of the large cities in this direction, as Norwich, Leicester, Yarmouth, and York, having suffered incredible losses. In Norwich 51,000 are reported to have died, and, at the least, 100,000 in London; for as we are informed by Barnes 50,000 corpses, arranged in layers, were buried in large pits dug for the purpose. It is said that in the whole country scarcely a tenth part remained alive; but, as Dr. Hecker justly remarks, this estimate is evidently too high.

Still pursuing the same course, or northern direction, the plague next visited Scotland, where also it committed the like devastations as in England—except in the mountainous districts of that country, which were scarcely at all affected. Ireland, also, was much less heavily visited than England, which was, doubtless, to be attributed to the fact that this country was situated on one of the boundaries of the track pursued by the disease.

From England the contagion, according to the language of the historical writers, was carried to Bergen, the capital of Norway; but, as I should say, from England the morbific line next extended itself, by some invisible path, to the above-mentioned town. From this point it gradually spread, by its own peculiar and well marked course, through this country, and thence to Poland and Russia; which it did not reach until two years after its appearance in the south of Europe.

In Norway, the plague commenced in its most frightful form, with vomiting of blood; and, throughout the whole country, spared not more than a third of the inhabitants. The sailors found no refuge in their ships, and vessels were often seen driving about on the ocean, or drifting on shore, whose crews had perished to the last man.* In Poland, the disease seems to have been most severe, for the inhabitants died in such vast numbers, that scarcely a fourth part, it was calculated, remained alive. In Russia, also, the mortality was great; so that the same scenes of affliction and despair were exhibited here, as occurred in those nations which had already passed the ordeal. The same mode of burial—the same horrible certainty of death—the same stupor and depression of spirits. In Russia, too, the voice of nature was silenced by fear and horror; and, in the hour of danger, fathers and mothers deserted their children, and children their parents.†

Turning to the accounts transmitted to us, of the volcanic and other phenomena observed during the route just described, we find it recorded, that soon after the plague had broken out in the island of Cyprus an earthquake, accompanied by a frightful hurricane, shook the foundations of the island. The sea overflowed, the ships were dashed to pieces on the rocks; and few outlived the terrific event, whereby, according to the writers of that period, this fertile and blooming island was converted into a desert.* Pursuing the course of these grand revolutions further, to quote the language of Dr. Hecker, we find notice of an unexampled earthquake, which, on the 25th January 1348, shook Greece, Italy, and the neighbouring countries; Naples, Rome, Pisa, Bologna, Padua, Venice, and many other cities suffered very severely; while many whole villages in the surrounding districts were swallowed up; castles, houses, and churches, were overthrown, and thousands of persons buried in their ruins. In Corinthia more than thirty villages, together with all the churches, were demolished, and more than a thousand corpses were drawn out of the rubbish; while the city of Villach was so completely destroyed, that a few only of its numerous inhabitants escaped. Not only were cities destroyed, or left in ruins, and whole villages swallowed up, but it was also found, that, when the earth ceased to tremble, mountains even, according to the testimony of writers of that period, had been removed from their position.

---

* *Torfaeus. Historia rerum Norvegicarum.*

† *Richter, as quoted by Hecker.*

Recurring to the events of the same kind, which were observed in the other countries of Europe visited by the disease, we shall find, that destructive earthquakes occurred in France, England, Denmark, Sweden, Poland, Silesia, and much further north; for, in consequence of the violent concussions, towering icebergs formed, we are told, on the coast of East Greenland, so that no one since that period has been able to penetrate beyond that shore. Mezeray, speaking of these phenomena, says, "a universal concussion of the earth, both in France and the countries to the north, overturned whole towns, rooted up trees and mountains, and filled the plains with chasms so profound, that it appeared as if hell was about to swallow up the whole human race." These destructive earthquakes continued to recur throughout France, England, Germany, and the northern countries, as well as Italy, until the year 1360, which was beyond the period that has been designated as belonging to the great mortality; for the time, when the black death raged with destructive violence in Europe, was, with the exception of Russia, from the year 1347 to 1350. The disease, it is true, continued to recur at different periods up to the 17th century; but these irruptions were neither so severe nor so general as the former, and partook more of the nature of endemic than epidemic complaints.

---

* *Deguignes op. cit.*, p. 225.

With respect to the other, or atmospherical phenomena, these, as we are informed by Dr. Hecker, began to appear as early as 1336, three years after the commencement of the plague in Europe. But we are not furnished with a detail of the whole of the vicissitudes, which were observed, or the order of their succession, as the writers of that period dwell principally on the rains, floods, and inundations, which were experienced; not only because these phenomena attract more attention at the time from their nature and character, but also because they are productive of great and irreparable injury to the earth and its inhabitants. I should conclude, however, that these rains and floods were preceded by great droughts and dry seasons; not only because we have seen that such was actually the case in China at this period, but also because we shall find, that this order has been observed in all the instances, of which we have any authentic detail. This inference is strengthened by the fact, that one historian of this period states there was an abundance of provisions in the granaries at the commencement of the plague; for it will frequently be found, that the droughts, and hot and dry seasons, are as favourable to vegetable production, as the rains and floods, which subsequently occur, are unfavourable.

The first particulars, however, of which we have any precise account, are the floods, which occurred in the vicinity of the Rhine and in France in 1338, and which could not be attributed, says Dr. Hecker, to rain alone; for everywhere, even on the tops of mountains, springs were seen to burst forth, and dry tracts were laid under water in an inexplicable manner. The order of the seasons, also, continues this writer, seemed to be inverted: rains, floods, and failures in the crops were so general, that few places were exempt from them. The consequence of failure in the crops was soon felt, especially in Italy and the surrounding countries, where, in one particular year, a rain, which continued for five months, had destroyed the seed. In the larger cities they were compelled in the spring of 1347 to have recourse to a distribution of bread among the poor, particularly at Florence; where they erected large bakehouses, from which 94,000 loaves of bread, of 12ounces each, were dispensed daily.

The same inversion of the seasons and the same results, famine, accompanied by returns of the disease, were felt more or less in all the countries of Europe, although not to the same extent; so that, as one writer expresses himself, " children died of want in their mothers arms; and want, misery, and despair were general throughout Christendom.*

" Many other atmospheric phenomena were also observed during the epidemic period, for great and extraordinary meteors appeared in many places, and were regarded with superstitious horror. A pillar of fire, which, on the 20th December 1348, remained for an hour at sunrise over the Pope's palace in Avignon; a fireball, which, in the same year, was seen at sunset over Paris, and was distinguished from similar phenomena by its longer duration, are also recorded in the chronicles of the age." *

---

* *Muratori.* *Tom.* 2, p. 524.

Such are the events, says Dr. Hecker, which took place at the time of the eruption of the black death. Contemporaries have explained them after their own manner, and have thus, like their posterity under similar circumstances, given a proof, that mortals possess neither senses nor intellectual powers sufficiently acute to comprehend the phenomena produced by the earth's organism; much less scientifically to understand their effects. To attempt five centuries after that age of desolation to point out the causes of a cosmical commotion, which has never recurred to an equal extent; to indicate scientifically the influences, which called forth so terrific a poison in the bodies of men and animals, exceeds the limits of human understanding. If we are even now unable, with all the varied resources of an extended knowledge of nature, to define that condition of the atmosphere, by which pestilences are generated, still less can we pretend to reason retrospectively from the 19th to the 14th century; but, adds this writer, with much force, if we take a general view of the occurrences, that century will give us copious information, and, as applicable to all succeeding times, of high importance.

We will now turn to that disease, which has visited the earth in our own day, in order to see if

---

* *Hecker, by Babbington*

the same phenomena have been observed during the march of the epidemic cholera. This disease, as is well known, commenced in the province of Bengal, in 1817, springing up spontaneously in various and different parts of the immense plain which is formed, or rather bounded, by the Delta of the Ganges. It then extended itself in almost every direction, at one and the same time; and, within the short space of a few weeks, stretching from the most easterly borders of Poonea and Syllet to the extreme borders of Balasore and Cuttack; and reaching from the mouths of the Ganges nearly as high as its junction with the Jumna.

As long as the epidemic was confined to the province of Bengal, observes the writer of the Bengal report, it at once raged simultaneously in various and remote quarters without evincing a predilection for any one tract, or district, more than another—or anything like regularity of succession in the chain of its operations. "But soon after reaching the point before mentioned, or the junction of the Jumna and Ganges, the epidemic began to show one of the most striking peculiarities, which characterized its march. It no longer pushed its influence, without distinction or apparent choice, in all directions and throughout every tract coming in its way; but began to affect *particular lines*, and to fix itself in particular divisions of the country, wholly restricting itself for the time to the course of those lines and divisions."

But, although the disease extended itself in various and different directions by these itinerary lines, still, it may be seen, by a reference to the history of the disease in this part of the world, that its principal route was in a westerly direction across the provinces of Bahar, Allahabad, Malwah, and Khandeish, to Bombay—for the other lines marked out by the disease may be considered as branches or offsets of the principal trunk. It was in August 1818, that the disease reached Bombay, being exactly a year after its commencement in Bengal.

With respect to the intensity of the disease, or the mortality, which was produced by it in this part of the world, it is unnecessary to dwell on this point at the present moment; not only because the facts themselves must be fresh in the recollection of all, but, also, because these circumstances will be more particularly dwelt upon hereafter. We may, therefore, pass on at once to a consideration of the terrestrial and other phenomena, which were observed before and subsequently to the appearance of the epidemic.

Referring to the events, that have been recorded of this kind, we learn, that, although earthquakes are very uncommon in India, they have been experienced very frequently, and, almost constantly, since the commencement of the epidemic. As is well known, this modern scourge of the human race commenced its ravages in the province of Bengal, in August 1817. In October several shocks of an earthquake were felt in Ganjam and Berhampore:

on the 16th of the same month five shocks were felt in the course of a few minutes at Benares, and about the same time at Cawnpore, and in the camp of the central division of the Bengal army. No particular convulsion appears to have been experienced again until 1819, when an earthquake—a phenomenon, to use the words of a writer in the *Madras Courier*, very unusual, we might, we believe, almost say unprecedented in this part of India—occurred on the 16th of June in various parts of the Peninsula; but more particularly in Cutch, which appears to have been the centre of the shock. So little known is such a visitation, observes the above authority, that the moonsif quoted his Hindoo shasters as foretelling that an earthquake would *some time* happen.

The effects of the shock in Bhooj are thus described by the above writer:—After two slight motions, that lifted the chairs, the tower near which Capt. Macmurdo was sitting, after heaving and rolling in a most awful degree, gave way at the bottom, and crumbling down buried guns and carriages in the rubbish; a moment after the towers and curtains of the fort wall and upwards of 15,000 houses were reduced to ruins. This shock lasted about two minutes, but many slight concussions were also experienced during the night. On the next day the earth was frequently in motion, until about a quarter to 10, when a severe shock, that lasted nearly 50 seconds, was experienced, and brought down a number of shattered buildings. Until the beginning of

August no day passed without some slight shocks; subsequently they became less frequent, only occurring at uncertain periods of many days interval, until the 23rd of November, which appears to have been the last distinct one. During the first convulsion nearly 7,000 houses were overturned, and 1,150 people buried in their ruins. The shock extended in a direction from north-west to south-east; and the utmost limits, within which the earthquake was felt, were, as far as it was known, Catmandoo in the north, Pondicherry in the south, Calcutta to the east, and the mountains of Belloochistan to the west. Although the appearance of the country in Cutch shows, that it has suffered, at some period, from convulsions of this nature; and although there are strong signs of volcanic matter thickly scattered over its surface, still there does not exist *even a tradition* of an earthquake of any violence having occurred there before. The lofty minarets of Ahcmedabad, which were thrown down, had stood something more than four centuries: an evidence that no such convulsion had taken place there within that period of time.

Although no earthquake, so severe as the preceding, has been experienced in India, that I am aware of, since that period, shocks of lesser magnitude have continued to be felt from time to time to the present day. This was more particularly the case in the years 1827 and 1828. At the commencement of the former year many houses were destroyed in Hyderabad, and slight shocks were felt at Calcutta and Burdwar and Vizagapatam in the same month.* On the 29th October the valley of Nepaul was convulsed by an earthquake, the shocks being from south to north. A severe shock was also felt in Sylhet, while the fort of Kolitaran was destroyed by the same convulsion, 1,000 persons being buried beneath the ruins.† The same accounts bear evidence of the fact, that these concussions had been attended, as usual, with the appearance of the epidemic; for we find added, it was computed that no fewer than 30,000 victims had perished from cholera in Lahore and the camp. So again the Calcutta *John Bull*, in mentioning the circumstance of some shocks having been felt at Dacca, remarks, that the natives are sickly, and some cases of cholera have of late occurred. But the best proof of this remarkable coincidence will be found in the following extracts from the *Calcutta Government Gazette*, of the 2nd August. The native papers, observes the writer, have given us a notion of the extent, to which the cholera prevailed this year in Rajpootana and the devastation committed by it at Jepur; but we were not before aware of its wide and wasting ravages in districts nearer to the eastern provinces. By letters from Jubulpore we learn, that the whole tract from Rewa thither has been equally affected; and that on a march made from Sagur to Jubulpore not a day passed without encountering large villages wholly deserted, the survivors having fled from the pestilence which had left but few to effect their escape.

---

* *Asiatic Journal.*

† *Madras Government Gazette.*

Independent of the above terrestrial phenomena, we also find that the same remarkable coincidence, or the inversion of the seasons, and which was observed at the period of the black death, marks the history of the epidemic cholera in India. This circumstance has been particularly noticed in that part of the world; for there the year being divided into the hot, the rainy, and the cold seasons, —each characterized by a peculiar state of the atmosphere, which continues, with little or no interruption, for certain fixed periods—any alteration in the accustomed heat, or dryness, or moisture in the air, is better observed and attracts greater attention than in climates, where the weather is more or less changeable during the whole year. These atmospherical vicissitudes commenced in India in 1816: a year marked by the absence of the accustomed rains, and the prevalence of great heats and consequent drought; so that the spring crop of grain was entirely destroyed. In the western parts of the province of Bengal the drought was so uncommon as to dry up the rivers. In the upper provinces, says Mr. Jameson, the extraordinary scantiness of the rains was yet more remarkable. From Benares upwards, Oude, the districts within the Doab, and those west of the Jumna, were dried up by the long continued and unceasing heats. In September this unwonted drought gave way, and was succeeded by heavy and incessant rains for many days, so that the whole face of the country was laid under water.* The ensuing cold season, also, both in the lower and upper provinces was raw, damp and unpleasant, and throughout cloudy with frequent falls of rain. February, says the writer just referred to, had more the appearance of an autumnal than of a cold weather month.

The next year (being that in which the epidemic commenced) was characterized by a very close sultry summer and autumn, and an excessively rainy season. The weather should now, according to the common course of things, adds the writer of the report, have become cool, settled, and fair: but the continuance of unwonted humidity and warmth in the air, and the frequent occurrence of rain throughout the month (November) proved, that the remainder of the year was to proceed with the same strange unseasonableness and insalubrity as that, which marked the early part of its course.

The following year (viz. 1818) was remarkable for the like irregularities in the seasons. The hot weather set in about the 20th of February, being earlier than usual: instead of continuing, however, until the beginning of June, as is commonly the case, heavy rains were experienced about the end of

---

* *Bengal Report.*

February. This sudden change, says Mr. Jameson, is worthy of particular notice: because *it was at this very time* that the epidemic, after dying away in November and December, and being nearly exhausted during January, took head; and, amongst the natives, raged with indiscriminate violence until the end of the following July.*

From this time, said one writer, while speaking of the remarkable vicissitudes, that had been experienced in the preceding years, the seasons, after so long a period of extraordinary deviation, seemed inclined to return to their ordinary course, and to abide by the laws marking their natural progress and succession. But this hope proved to be fallacious; for the like vicissitudes and the like changes have been experienced, more or less, from the above period to the present day; there being hardly an instance known of a visitation of the epidemic without its being accompanied, preceded, or followed, by changes in the weather or the seasons. In fact the disease, to quote the words of another observer (and the remark has been made by most persons who have expressed any opinion on the subject) has never appeared in India during that portion of the year usually characterized by clear and serene weather, without producing some change.† We thus see that there was not only a remarkable coincidence, as the writer of the Bengal report remarks, between the extraordinary irregularities manifested throughout India in 1816 and 1817, and the rise of the epidemic; but, also, that its subsequent abatements and revivals were accompanied by similar vicissitudes.

---

* *Bengal Report.*

† *Asiatic Journal,* 1818, p. 184

As is well known, the next country visited by the disease, during its march from Asia to Europe, was Persia; in the southern and middle portions of which kingdom it committed great and extensive ravages. The epidemic commenced at Bender Abassi in July 1821, and, after attacking Shiraz, gradually extended itself in a northerly direction through the heart of the country. It was not, however, until the middle of 1823 that it reached the towns situated in the north of Persia and on the southern borders of the Caspian Sea. Referring to the phenomena, which now engage our attention, we learn that, after some slight shocks had been felt at Bombay, and the neighbouring districts, in 1821, a concussion was experienced at Khooskezund on the 11th June 1824; but the shock was not very severe, for the accounts merely say that the walls of the houses were cracked and the mountains covered with dust. Again, by a letter from an eye witness, dated Jehel Murmal, near Shiraz, we find, that, on the morning of the 25th of June, the inhabitants were disturbed by the shock of an earthquake of much greater force than the preceding. The shock must have been a very severe one, for an Armenian clergyman, writing to a friend at Calcutta, states that Kazeroon, Feruzabad, and the surrounding villages, suffered the same calamity, while the number of persons destroyed in Shiraz alone was reckoned at about 200. Slight shocks continued to be felt at various intervals until the following year, when another severe concussion, equal almost to the preceding one, was experienced at Shiraz.*

Having thus traced the disease by the principal route from India to Europe, as far as the borders of the Caspian Sea, we may now return to a consideration of the phenomena presented to our notice by what may be termed an offset of the epidemic. After attacking the whole of the towns situated at the mouth of the Persian Gulf, the disease branched off in two particular and distinct directions, —the one by the route just described and the other along the Arabian side of the gulf, until it reached Bassorah and Bagdad, situated on the rivers Euphrates and Tigris—this was in the year 1821. The epidemic then continued its course to the northward as far as Annah, a town situated on the borders of the desert, which separates Mesopotamia and Syria; but, after reaching this point, subsided until the following spring, when it broke out at Moussoul, situated 60 miles to the northward of Bagdad. After infecting the intermediate towns between Moussoul and Antab on the boundary of the Syrian provinces it reached Aleppo in November, in which place, for three days, 300 victims fell daily beneath its poisonous influence. The epidemic then subsided, but reappeared the following year, and after ravaging the neighbouring districts, at last gained a footing on the shores of the mediterranean. This however, as we have remarked in a former part of this work, was the limit of its extension in this direction.

---

* *Asiatic Journal, Vol. XXII.*

During the above period a phenomenon occurred, similar to those, which had been observed in other districts visited by the disease: this was an earthquake, that took place on the line of route pursued by the epidemic. On the 13th August 1822, as we are informed by Mr. Barker, the British consul, in a communication to the Levant Company, Aleppo, Antioch, every village and every cottage in the Pashalic, and some towns in the adjoining ones, were, in 10 or 12 minutes, entirely ruined by an earthquake, and had become a heap of stones and rubbish; while, on the lowest computation, 20,000 human beings, about a tenth part of the population, were destroyed, and an equal number maimed or wounded. Slight shocks continued to be felt in the same spot, until the 9th October, when they entirely ceased.

With respect to the atmospherical vicissitudes which occurred during the march of the cholera by the routes just described, we have, unfortunately, no detailed or collected accounts particularly as regards Persia and Mesopotamia; for if such phenomena have only been partially and irregularly recorded by the scientific in Europe, it is no wonder that they have escaped the observation of, or have not been noted by, the casual traveller, or the solitary resident, in these demi-civilized parts of the globe. There are, however, some facts on record, which prove that particular and unusual atmospherical phenomena were observed here, the same as elsewhere. Thus the apothecary-in-chief of the hospital in Cairo stated, in a letter addressed to the editors of one of the French journals, that the sky on the approach of the cholera to that city, and for some days before, produced a feeling of horror, from the peculiar appearance of the sun; the rays of light being obscured, although there was not a cloud. All the inhabitants of Cairo experienced at this period, adds the above writer, indisposition, as want of appetite, indigestions, flatulencies, weight in the head, slight diarrhœa, weakness in the limbs, etc.; symptoms which in the majority of cases were the forerunners of cholera itself. Dr. Hedenhof, also, the Swedish savant, in a letter published in the *St. Petersbourg Journal*, states, that all the east (Ægypt, Asia Minor, the Archipelago, Turkey, etc.) had been during the preceding months a prey to an influenza, accompanied by gastric symptoms. This epidemic, continued the writer, although of a different nature from cholera, which preceded it, appears to be subject *to the same atmospherical influences.* The winter, he adds, had been more severe than was ever known before in these countries. At Tifles and Georgia, where cold weather is scarcely known, the thermometer of Rheaumur has been 30 degrees below the freezing point.

We have thus followed the disease from its origin to the shores of the Mediterranean and Caspian Seas, and have afforded satisfactory proof, that terrestrial commotions were the constant accompaniments of the epidemic cholera during its course from east to west. Could space and time be afforded me, I might also show, that the same phenomena were observed along the route, which the disease took in the opposite direction; as well as after it had passed the Caspian Sea and extended itself through the heart of the Russian dominions to the other countries of Europe. Wanting, however, a detailed and connected account of these phenomena, I shall content myself with observing, that earthquakes were felt after the appearance of the disease in Odessa, in Northern Europe, and along the Rhine; while, even in England, where such phenomena are almost unknown, slight shocks have been felt occasionally from that time to the present.

With respect to the atmospherical changes and vicissitudes in Europe, these phenomena, from causes, which will be more particularly explained hereafter, have not been so frequent or so well marked as in other situations; while the variable nature of the climate, in this portion of the globe, makes such changes less noted than in the East or in India. They have, however, been noted and observed by a variety of individuals; and Dr. Forster, while alluding to these phenomena, says, "I consider what I call the epidemic period as having begun as early as September 1828, when that extraordinary *lumen zodiacale* was seen to stretch across the heavens. I have, also," continues this gentleman, "traced a succession of atmospheric changes since that period, so that the spring of 1829 became remarkably unhealthy; while the mortality in some countries was prodigious; and the cold of the summer in some parts of Europe as extraordinary. I was at Spa, in the end of May 1829, and I remember, *while examining the substance thrown out by an earthquake* there, to have found the cold as great as in winter; and, on the morning of the 8th of June, there was ice on the puddles of water by the banks of the Meuse, near to the town of Namur; I learned, also, from couriers, that the cold was severe all along the Rhine, and even in Austria. At Louvain they told me everybody was more or less ill; and I heard the same at Aix-la-Chappelle: a warmer air began at Cambrai, and it was as warm as usual at Paris; but, in Spain I find the cold was great. The winter of 1829-30 which followed, was one of unusual severity all over the world; even in the south of Spain and in Africa snow lay on the ground, and in most parts of Europe covered it, from November 1829 to the end of February 1830. The cholera morbus then broke away from India and began its deadly course towards Europe, but did not arrive in Russia until the following spring. The plague, however, broke out at Jassy; and in Moldavia severe illness prevailed." During the present year (1831) the cholera morbus, continues this writer, has been making a certain progress, while milder sorts of epidemics have either been its precursors, have followed in its train, or have appeared in its outskirts. In England and France, for example, we have had the grippe; the epidemic cough in July, and the affection of the bowels in August and September. Other and various epidemics are spoken of in other places in Europe and Asia.*

The greater number of physicians, says one author, speaking of the slighter affections, which ushered in the epidemic cholera in Berlin, attributed these accidents to the influence of the summer; which was hot and wet, with a remarkable absence of all storms. A singular and almost unknown circumstance, continues the same writer, also contributed to augment the humidity of the atmosphere: this was the inundations of the banks of the Spree —a phenomenon which was several times repeated without its being possible to explain properly the cause. These spontaneous inundations were observed at the same time in Russia, in Poland, and a great part of Prussia.† In England, also, the same remarkable vicissitudes have been experienced from the above period to the present day; and, what is worthy of note, the same order has been observed in their progression as in the instances before referred to; for the epidemic was preceded and ushered in by sultry close weather and an unusually hot and dry summer; while it has been followed by great and unexampled cold and unusually wet and rainy seasons with floods and inundations in particular parts of the country.

---

* *Essay on the Cholera Morbus.*

† *Relation de l'Epidemeque de Cholera qui a Regnè à Berlin.*

In addition to the above there are certain other phenomena, which have been recorded by different writers, and which deserve consideration at the present moment. One is the appearance of a fixed cloud, and the other the occurrence of luminous arches, or the Aurora Borealis. The appearance of a fixed cloud,—a phenomenon, says Mr. Jameson, which has frequently been observed to attend all epidemics or plagues, was also remarked in Calcutta. *To the experienced eye it clearly foreboded*, whenever observed, *the return of cholera.* This phenomenon may be regarded, in conjunction with others, as a sure sign of the existence of volcanic action; for, as Dr. Stukely informs us, it is generally observed, in the history of earthquakes, that they begin in calm weather *with a black cloud.* In fact, the inhabitants of those countries, much subject to earthquakes, consider the appearance of these clouds as sure signs of an approaching catastrophe.

There also seems to have been a great and unusual number of fiery arches observed immediately previous to the introduction of the cholera into Europe,—a circumstance which has also been remarked at other epidemic periods, as in 1610, when the general influenza prevailed. Thus an arch of prodigious size and grandeur stretched across Europe on the 29th September 1828, *in a direction from east to west.*

Independent of the fact of the appearance of these arches at periods, when so many other atmospherical phenomena are observed, it would seem, that they obey the same laws as those effects of volcanic action, which have been before described. Thus the Aurora Borealis, observed in England in 1826, was about eight or nine miles broad, but its *visible length* in an east and west direction, from any one place, was about 500 miles. Mr. Dalton also informs us, that there was a luminous arch in Cornwall, in September 1828, simultaneously with a remarkable Aurora of many arches over the whole of Aberdeenshire. This proves, says the above writer, that the meteor is sometimes active over a space nearly coincident with the extent of this kingdom.* We have also just before mentioned that one of these arcs stretched across Europe in the same year, and in the same direction. I should, therefore, infer from the above facts, not only that these arcs of light are in some measure connected with volcanic action; but, also, that their appearance is indicative of the existence of this process at the time and place where they are observed. If so, we have another proof afforded us of the operation of this cause, at the time of the outbreak of the epidemic cholera in Europe. Dr. Ferdinand Jencken, also, in speaking of the vicissitudes observed at the same period, adds the northern lights visible in southern regions, the formidable inundations, and many other phenomena of the same description, the unprecedented hail storm in Constantinople, and the meteoric phenomena at Berlin are evident proofs of telluric influence. This influence, or power, which necessarily implies the vitality or organism of the earth, seems to be a favorite doctrine with Dr. Hecker and some other German writers. But as Dr. Babington has justly observed, with reference to this opinion, we are constantly furnished with proofs that that which affects life is not life itself. To assume, therefore, causes, of whose existence we have no proof, in order to account for effects, which after all they do not explain, is making no real advance in knowledge; and can scarcely be considered otherwise than an indirect method of confessing our ignorance.* If, however, instead of supposing that the earth is endowed with an organism or vitality of its own, we infer, that the phenomena, which we have now been considering, are the effects of volcanic action, and that this action does not pervade the whole globe, but is confined to particular lines, we not only infer the operation of an agent, with whose existence we are acquainted, but we are also able, at the same time, to account for all the phenomena witnessed on these occasions.

---

* *Phil. Trans. An.* 1828.

---

* *Preface to the Translation of Dr. Hecker's work, by Dr. Babington.*

It is evident, therefore, that the same terrestrial commotions and the same atmospherical phenomena accompanied the march of the epidemic cholera and the black death of the 14th century, with this only difference, that the effects referred to were more intense and more general, during the latter than the former period. Not only were the same phenomena observed at both periods, but, what is still more remarkable, the intensity of these effects, and the violence and extent of the malady which accompanied them, kept pace with each other. That such was the case, there can be no doubt; for as, at the period of the black death, earthquakes were, as Dr. Hecker observes, more general than they had been within the range of history, so, also, the destructiveness of the plague, which prevailed at the same time, was greater than has been witnessed since—for we are told that one-fourth, at least, of the Old World, was swept away in the short space of four years.

In China more than 13,000,000 are said to have died; while it was reported to Pope Clement, that, throughout the East, independent of China, 23,000,000 of people had fallen victims to the disease.

In Europe the ravages of the disease were nearly as great; for Dr. Hecker concludes, of all the estimates of the number of lives lost in Europe the most probable is, that altogether a fourth part of the inhabitants were carried off. Taking the entire population, therefore, at this period at 100,000,000, a calculation sufficiently near for the purpose, it may be assumed that 25,000,000 were swept away in this quarter of the globe alone.

If we now turn to the accounts, that have been given of the mortality produced by the epidemic cholera, we shall find, that it falls very far short of that of the black death. In India the mortality has been calculated by M. Moreau de Jonnes at two millions and a half at each visitation: but this calculation is evidently too high; for, although there probably died the above number of persons, during the first two or three years of the prevalence of the disease, the mortality could not have been anything like this in the subsequent visitations; as the epidemic was then more limited in its range and confined to particular towns, or particular parts of the country. We may however assume, that from 1817 to 1820, when the disease prevailed generally, from five to six millions of people were swept away by the cholera in India

The mortality in other countries in the East was, in general, about the same—in some places even more; for the preceding writer calculates, that, supposing India lost one-sixth of her population, in Arabia one-third of the inhabitants were cut off; in Mesopotamia a fourth; in Armenia a fifth; in Persia a sixth; and in Syria a tenth.

When however we turn to Europe, we find a great and striking difference between the mortality of the black death and the epidemic cholera; for in Russia, the first country visited, 60,000 only perished—being not more than a twentieth of the population: in many other countries the proportion was still less. Now in the black death the country, in which the ravages of the disease were less than any other, was Germany; and yet here, a million and a half of people were carried off by the pestilence. But of all the places attacked by the epidemic cholera the smallest number of deaths, in proportion to the population, was in London—for it only amounted in two visitations to about 3,000 or as some say 5,000. In the black death there perished 100,000, although the population was so much smaller at that period than at present.

This difference in the mortality cannot be ascribed to a difference in the nature, or violence of the two epidemics, now under consideration; for the proportion of deaths to the number attacked has not varied so much as might at first sight be supposed. Unfortunately, we have no exact, or general, details of the proportion of deaths to the number attacked in the black death, although it has been casually mentioned, by one writer, that three out of five of those attacked died — a proportion not much greater than what has been observed in the epidemic cholera. If so, we must conclude, that the greater ravages of the disease in the one case than in the other are to be ascribed, not to a difference in the nature of the maladies, but to a difference in the intensity and power of the operating cause, whatever that may be. This inference seems confirmed by the fact, that the mortality in both diseases varied much in different situations or different countries; for, independent of the difference of the mortality in the East and the West, as great a difference was sometimes remarked in particular countries, even in the same quarter of the globe. Thus Italy is said to have lost half its inhabitants; whereas in Germany not more than a twelfth part were cut off. In England, again, the ravages of the disease were very great,—not more than a tenth part of the inhabitants having, it is said, been left alive in some places: but in Ireland, and the north of Scotland, the extent of the disease, and its ravages, were very limited. The same difference has been particularly remarked during the prevalence of the late epidemic.

Compare, for instance, the mortality of the cholera in London during the year of its prevalence in this capital, being (as we have just stated) about 5,000 out of a population of a million and a half, with the ravages of the disease in some parts of India, as at Punderpoor. When the disease first commenced in this town, observes Captain Sykes, 350 are described to have died in one day, tumbling over each other in the public streets, as if knocked down by lightning; while the number of deaths, as we are informed by Mr Coates, amounted, in a few days, to 3,000. So, also, when the disease attacked the army of the Marquis of Hastings, encamped on the banks of the Sinde in Bundlekund, it assumed a most deadly and fatal form, sparing neither sex nor age in the undistinguishing virulence of its attacks. The old and the young, the European and the Native, fighting men and camp followers, were alike subjected to its visits, and all equally sunk, in a few hours, under its most powerful grasp. The mortality was at its height from the 14th to the 22nd; during which fatal week 761 out of 7,000 fighting men and 8,000 camp followers, or one-tenth of the whole, were cut off.* Again, let us pass on to another part of the world, to the route, which the disease took from the Persian Gulf to Asia Minor; and where that convulsion occurred, which has been already described. At Bassorah, one of the first towns visited, 15,000 persons were carried off in a few days—being one-third of the population; while, at a spot, where the principal concussion was felt, the following particulars are furnished respecting the irruption of the disease:—Twenty peasants of Swedia, robust, vigorous, and in the flower of life, writes the same gentleman,

---

* *Bengal Report.*

to whom we are indebted for the account of the earthquake, were labouring at the harvest, when, on the 9th July at noon, one was suddenly attacked, and the others, in a short time, showed symptoms of the disorder. In three hours the entire band was exhausted; before sunset many had ceased to live: and, by the morrow, there was no survivor. This variation in the intensity of the disease, and its little virulence in Europe, could not have been produced by the greater mildness of the disease, or the difference of climate and constitutions, of those affected; for the proportion of deaths to those attacked has varied but little in these different situations. The general mortality, observes M. Moreau de Jonnes produced by the cholera, has varied much in different countries, without our being able to discover the cause, since its principle preserves *everywhere the same violence;* and sometimes kills in less than two hours the persons it attacks, even in those places where the extent of its ravages are the most limited. It has seldom, says this writer, caused less than a third of the persons attacked to perish; generally it carries off more than a third, and, very often, the three-fifths, the two-thirds, or even the six-sevenths. Thus, although the mortality, when compared with the population, was so small in Russia, still it bore the same ratio to the number attacked as in other places; for out of 100,000 patients 60,000 died. The same remarks apply to the mortality in London, and all other places, where the range of the disease was at all limited,—for although the influence of the Cholera, in respect to its propagation and extension, remained, as M. Moreau de Jonnes has justly remarked, singularly circumscribed in the midst of the immense population of London, its pestilential power did not suffer any diminution, since of *two persons attacked, one died.* If, therefore, we find that the virulence, or intensity, of the disease, has been the same in all places visited by the epidemic, at the same time that its range has been more limited in one situation than another, we can only infer, that this variation is produced by the greater or less influence of the operating cause. Granting this, and presuming, also, that this cause is the process, to which the term volcanic action has been applied, we have proof afforded us, by the historical detail now given, that terrestrial concussions and other signs of the existence of volcanic action were most violent, and more frequently observed in those situations, where the extent and ravages of the disease were the greatest. If so, we are furnished with another link, in the chain of presumptive evidence, which has been advanced in support of the conclusions before drawn, that epidemic diseases are produced by the operation of volcanic action in the interior of the globe.

CHAPTER III.

Having thus briefly detailed the facts, and stated the arguments, which would appear to lead to the conclusion, that the cause of the production of epidemic diseases is the same as that which gives rise to the eruption of the volcano and the shock of the earthquake; we may now pass on to a consideration of the manner, in which these several effects are produced. In so doing we unfortunately enter a wide field of conjecture and doubt; as no theory has yet been proposed which appears, to the generality of geologists, to account for all the phenomena, known to depend on volcanic action. It is impossible, therefore, to refer to any acknowledged theory in order to account for the mode in which these several effects are produced; as might be the case, if we had clear and distinct notions of what volcanic action really is. Under these circumstances, it only remains to state the different theories entertained on this subject, in order to ascertain, if they will, either separately, or collectively, account for the production of epidemic diseases. Various are the theories, which have been proposed by different individuals at different times, in order to elucidate the nature of volcanic action; but three only would seem to deserve consideration in the present day.

Until lately the most generally received was that, which assumes the existence of a great central heat in the interior of the earth; the individuals who advocate this doctrine considering, that our planet was formerly a globe of fire — to which circumstance is referred all the phenomena known to arise from what has been termed volcanic action. According to this theory, the formation of the volcano is to be ascribed to secular refrigeration, or the slow diffusion of the primitive heat; for as, under such circumstances, the crust of the earth must contract, as it cools down, the pressure thus exerted on the internal and fluid mass would necessarily cause a portion of melted matter to be ejected, from time to time, on the surface—as we witness during volcanic eruptions. Another class of geologists, concluding with M. Houell in his *Voyage Picturesque*, that fire cannot exist alone, and without any pabulum, have referred volcanic action to a species of combustion; and various substances, which were supposed adequate to the purpose, have been named — as sulphur, petroleum, and other inflammable matter. The third, and last, theory to be considered is that, which depends for its formation on the brilliant discoveries of Sir H. Davy, as to the chemical composition of the alkalies, earths, and metals—substances, of which the crust of the globe is chiefly, if not entirely composed. This distinguished philosopher has shown, that the base of these substances is highly inflammable; and its attraction for oxygen so strong, that it will abstract it even from water; giving rise, at the same time, to a sufficient extrication of light and heat to constitute a genuine case of combustion.

Now, although it may be considered presumptuous in one, who is not a professed geologist, to attempt to unravel the mystery, which hangs over this subject, I would yet venture to remark, with reference to the first of these theories, that it is not sufficient to account for *all* the phenomena attendant on volcanic action; although several of them receive elucidation on this hypothesis. In the first place I may observe, that, independent of other objections, which have been urged against the theory by different writers, the matter, which issues from volcanos in different parts of the world, does not appear to come from a central reservoir, or common *focus*: for we should expect, that the vents, in this case, would be scattered irregularly over the surface; at the same time that they were found, while in a state of activity, to hold a general and common relation to each other. Such, however, is not the case; for volcanos are invariably grouped together in particular regions of the earth's surface, occurring, as Von Buch has already remarked, either scattered along particular lines of the earth's surface, or, else, united in clusters around some common centre;—hence the division into linear and central volcanos. It may also be stated, as a fact, that the volcanos in one region, line, or cluster, hold no relation with those in another and distant part of the earth—while it is as clearly ascertained, that the vents in one particular line, or cluster, communicate freely with each other. It would therefore appear, that the lava thrown out from volcanic vents is derived from *various and separate reservoirs,* instead of being confined in one common and central focus—a supposition in accordance with all the facts presented to our notice on these occasions.

Besides, although we might, by this theory, account for the ejection of melted matter from the interior to the exterior, at certain points of the earth's surface, it will never explain, why the phenomena, attendant on the eruption of the volcano, should vary so much at different times, or according to the date or period of its formation. Thus, when a volcanic vent has been formed, the matter ejected at first is almost entirely aëriform, consisting of smoke, aqueous vapour, and gases of different kinds: this is followed by the discharge of melted matter, or lava, which, together with the products just named, or a part only, continues to be thrown out, at intervals, for a longer or shorter period. After a time, solid matter is no longer ejected, but gazeous substances alone; until, at a still longer period, these products, also, cease to be given out. These different circumstances have occasioned volcanos to be divided into active and extinct, modern and ancient; according as they are in a state of activity or inactivity, and according, also, as their formation happened during or before historical periods. Now if each vent, on the surface, communicated with one central reservoir, there can be no reason why the products should vary so much in different regions, consisting of aëriform matter in one, and melted lava in another. Besides, this gradual increase and diminution in the state of activity of a volcano, and this variation in the products, at different periods, as well as the total inactivity of the volcano after a certain interval, would seem to show, that the action, which gives rise to these effects, is local and not general; and that it exists only for definite and not indefinite periods.

On the other hand, if volcanic effects be produced from the presence of melted matter in the interior of the globe, there must be combustion of some kind going on; for we can have no idea of fire existing alone without any pabulum, as has been already remarked. It seems difficult, therefore, to imagine how this combustion could have been kept up for so long a period; not only during all historical periods, but, also, for indefinite ages before the formation of man—as must be the case if the above theory be a correct one; for we have evidence of volcanic effects having taken place on the crust of the globe long before the present continents were upheaved. But, if we suppose, that this action is confined to certain portions of the crust of the earth, and that the substance, which gives rise to the process, is contained in separate and distinct reservoirs, we can readily understand, how, when once this action has commenced in one part of the globe, it should continue for a definite period and then subside; while, if materials exist, the same cause might again give rise to the same effect in another locality, and the process be thus going on for indefinite periods at different points of the earth's surface.

These circumstances, therefore, would seem to favor the next of the theories referred to; for they lead to the conclusion, that the action, which gives rise to volcanic effects, is simply one of combustion—only that we are unable to understand, how the common process of combustion can take place, or be kept up, without the presence of oxygen. True, it is, that we are totally unacquainted with the mechanism of the globe; or the means of communication, which may exist between the interior and the exterior—so as to afford the necessary supply of oxygen, in order to keep up the combustion. But, even then, this action would appear to be different from the process of combustion, as existing on the surface: for as the products of combustion, to quote the expression of Mr. Brande, always have reference to the combustible; the substances, given out from the vents of volcanos, cannot be referred to the combustion of either sulphur, petroleum, or other combustible matter existing on the surface. Besides, the accidental combustion of these substances, at short distances beneath the surface, and within the observation of man, gives rise, as the opponents of this doctrine have remarked, to a train of effects altogether different from those of volcanos; as we have proof of in the accidental burning of coal mines in many parts of Great Britain; in the combustion of masses of petroleum, as at Baku; and of sulphur, or bituminous matter, as at Macabila.

We are thus forced by the apparent failure of the other hypotheses, and by a sort of *reductio ad absurdum*, to regard the last of these theories, in order to see, if that will account for the production of all the phenomena, known to depend on volcanic action. Now it has been argued by those, who adopt this theory, that, although we are unacquainted with the metallic bases on the surface of the globe in their pure or primitive state, there must have been a time, when these substances existed uncombined with any oxygen. It is therefore fair to infer, that the process of oxygenation may still be incomplete in certain situations, and at those vast depths, to which air and water have not yet been admitted. If this be granted, all, that then seems necessary, in order to produce combustion, or inflammation, in these beds or veins of pure metals, is the sudden or accidental contact of atmospheric air or water. Now those acquainted with the daily and constant changes going on, not only on the surface, but, also, in the crust and interior of the globe, will not be surprised, if both atmospheric air and water should be able to penetrate, from time to time, to situations and depths, where neither the one nor the other had found access before. There seems, therefore, no *à priori* absurdity in imagining, as one writer has justly remarked,* that volcanic action may consist in a process of oxygenation, caused, in part at least, by the presence of the metallic bases, and their combustion, or union, with oxygen: while, also, I may add, it will explain nearly all the facts connected with the origin and continuance of volcanic action, at the same time that it accounts for those anomalies which belong to the other theories. As, however, it would be foreign to my object to enter into all the arguments, which have been advanced in support of the above theory (for the establishment of this, or any other theory, is not necessary, in order to prove my proposition), I shall content myself with referring the reader to works expressly dedicated to the subject; especially the article Geology, in the *Encyclopædia Metropolitana*, where the question has been fairly and scientifically treated. I may however remark, that, although neither hypothesis is sufficient, perhaps, to account for all the phenomena observed on the surface of the earth, they may each be in part true and the combination of the whole necessary, in order to explain the production of all those effects usually referred to volcanic action. Thus it is possible, that there is still a mass of heated matter in the interior of the globe; for as Baron Fourier has justly observed, the spheroidal form of the earth being that, which a fluid body would assume, if revolving in space, it is as probable that this fluidity should have been igneous, as aqueous. Besides, the disposition of the internal strata, shown by experiments with the pendulum to increase with the depth, as well as other considerations, more particularly the well ascertained fact of an increase of temperature from the surface downwards, seems to prove that a very intense heat formerly penetrated all parts of our globe; and lends countenance to the opinion, that our world is a mass of igneous matter in the act of cooling. If so, this great central heat, which will remain long after the surface has acquired its present temperature, may be sufficient to account for some of the phenomena supposed to arise from volcanic action; even should it have no connection with the commencement of that process, to which all the other phenomena must be immediately referred. Again: Although combustion, in the common acceptation of the term, cannot be the cause of the production of volcanic effects, as, if this were the case, the materials which occasion it must be, in part at least, of a different description from the combustibles, which exist on the surface; still, after this action has taken place and when it is kept up by other means, combustion, of the same kind as that which exists on the surface, may occur within the sphere of the volcanic *foci.* And, lastly, if the action itself be a chemical one, as I would infer, and if it be produced from the inflammation of the metallic bases, we shall be enabled to explain, not only the cause of the action itself, but, also, many of those phenomena which do not receive elucidation from the two other theories —such as the commencement of the process in one portion of the globe; its subsidence in definite portions of time, or during historical periods, and its recurrence in other situations; as well as the apparent anomaly of combustion taking place in closed reservoirs, and without the presence of atmospheric air, or oxygen.

---

* *Art. Geology, in the Encyclopædia Metropolitana.*

With these few observations, and leaving this point, viz., the immediate cause of the production of volcanic action as a point still in dispute, I may return to the subject, which more particularly engages our attention, viz., the manner in which epidemic diseases are produced by volcanic action. Now it is quite clear, from what has been stated in the preceding part of this paper, that one result of the existence of volcanic action is the generation of various gases; or, at the least, their evolution from the interior of the earth, and their diffusion in the surrounding atmosphere. This effect is most apparent during the eruption of the volcano, particularly on its first formation; as must be familiar to all, who have perused the accounts of such visitations. A remarkable example was afforded by the eruption in the island of St. Vincent in 1812, which began by an abrupt and dreadful crash from the mountain, called Souffriere; and was proclaimed, in a moment, by a vast column of thick, black, ropy smoke, like that of an immense glass-house. On the following day it appeared like a compact, pitchy column, rising perpendicularly from the crater to an immense height. Minor effects of the same kind are also observed during the occurrence of earthquakes.

But, in addition to the gazeous matter discharged from the craters of volcanos, and the fissures formed by earthquakes, at the time of the eruption of the one and the occurrence of the other, various gases are also given out from the bowels of the earth, *silently and invisibly*, before the above phenomena are observed—although, for obvious reasons, the source, whence the matter is derived, is not so evident in this instance as the former; for its diffusion in the atmosphere is so gradual as to be nearly imperceptible. The phenomenon, however, has been observed to precede, or to accompany, earthquakes so frequently, and to occur in situations and at times when no other reason can be assigned for its production, that no doubt can possibly exist as to the cause. Thus, in the memorable earthquake at Lisbon, in 1700, a thick fog was perceived on the morning of the fatal day both in that city and other places near; while a remarkable haze or mist, which obscured the sun's rays, was also visible on the *day preceding* the tremendous concussion, which laid Lisbon in ruins in 1755. Again: For some months previous to the eruption of Heckla, in Iceland, in 1783, the atmosphere of the whole island was filled with a dark, bluish, sulphurous vapour, or cloud, which was stationary in calm weather, and at others blown over the neighbouring countries. The same effect has been remarked, not only for some time before a particular earthquake, in the spot where this is experienced, but *in situations far removed from the centre of the concussion*—of which numerous examples have been recorded.

Remarking, therefore, that gazeous matter is thus given out from the bowels of the earth not only at the time, but antecedent to the eruption and the shock, it is necessary to ascertain how this evolution takes place. If the reservoirs, from which these gases are derived, exist at a comparatively slight depth beneath the surface, it is easy to conceive, that they may, under certain circumstances, escape through the superincumbent strata,—even when a pressure much less than that, which produces the shock and the eruption, is alone exerted. But it will, in other cases, be impossible to draw such an inference, as the solidity and nature of the superincumbent strata must prevent their escape in this direction; for although earthquakes are most frequent on tertiary formations and in alluvial districts, they are not entirely confined to these situations, but are also witnessed on secondary formations. It is clear, therefore, that the evolution of gazeous matter from the bowels of the earth, before any fissure, or vent, has been formed on the surface, could not take place through the interstices of the majority of the rocks composing those formations termed primary and secondary. To some other means then must we look for the production of this effect.

In so doing we are at once led to regard those natural outlets formed by the streams which penetrate to various depths; and convey to the surface that fluid, so necessary for the health and life of man. Now these streams, or springs, abound in all situations, being found in the hardest rock as well as in the soft and humid beds of alluvial tracts. They are, however, more abundant in the latter situation than the former—while they are comparatively rare in primary formations. If, therefore, springs penetrate to volcanic foci, to such channels we may, in all probability, look for the discharge of those gases, which escape from the interior to the exterior, before the formation of any vent or fissure. This inference is strengthened by the fact, that *thermal* springs exist in the neighbourhood of all active volcanos, at the same time that their production can generally be referred to the same epoch as the volcano itself; while, also, it has been found that the same mineral and gazeous matter is contained in their waters, as that which is given out from the volcanic vent. The relation, indeed, as Mr. Lyell justly observes, of almost all springs impregnated copiously with mineral matter to the sources of subterranean heat, seems placed beyond all reasonable doubt by modern research. More than this, we find that these springs continue to give out the same substances and to retain their increased temperature long after the volcano has become extinct; by which it would appear, that the products of volcanic action escape more readily by these channels than from the ducts of volcanos. It is clear, therefore, that the waters of mineral springs must penetrate to volcanic foci, in order to become impregnated with such products. But as the production of thermal springs can generally be referred to the same epoch as the neighbouring volcano, the question of most importance at the present moment is, do the same products, or, rather gazeous matter, escape by the same channels at other times, before any chasms have been formed, and in situations in which no other sign of volcanic action is in existence? That such is the case, we may infer from numerous phenomena. Thus previously to the concussion, or the eruption, the sea frequently swells up and makes a great noise, at the same time that the waters of the neighbouring springs are observed to become muddy and to overflow—effects which are frequently experienced at considerable distances from the spot, where the concussion occurs. Whether the waves, produced in the sea at the spot, where the concussion is felt, be the effect of the alteration in the level of the land, which forms the bottom, or whether it be partly the effect of some other cause, must be matter of opinion and discussion. But of this there can be no doubt, viz., that gazeous matter escapes in large quantity from the waters of the ocean, not only during eruptions and earthquakes, but, also, *before any shock has been experienced.* Thus, before the earthquake which happened at Oporto in 1755, the river opened, and seemed to discharge an immense quantity of *air.* Again: Previous to the earthquake which occurred in Calabria in 1638 the sea, as we are informed by Kircher, seemed to wear a very unusual appearance: those, who have seen a lake in a violent shower of rain all covered over with bubbles, may, says this writer, have some idea of its agitation. It is also recorded, that, at the same time, the fishermen were obliged to relinquish their occupations, and to land; for, though *there was no wind*, yet the sea, for some distance, appeared to be in an extraordinary state of ferment and ebullition. It is remarkable, also, that seamen sometimes observe a swelling of the ocean *without wind*, and before any shock has been experienced; and this fact Pliny mentions among the signs of an approaching earthquake. This phenomenon can only, we may presume, be ascribed to the escape of gazeous matter from the bottom of the sea; and this matter, we may further infer, is derived from the mouths of those springs, which rise up as freely beneath the waters of the ocean, as on the surface of the dry land.

This inference receives support from the fact, that the same agitation in the water has been observed in situations far removed from the centre of the concussion; and when no shock has been perceived, either then, or subsequently, in the solid crust of that part of the globe. This was very remarkable at the time of the earthquake at Oporto, just referred to. It was only in Portugal that any elevation of the superincumbent strata took place: but agitation, or movement, in the waters of the sea, rivers, etc., was observed in France, England, Germany, and even as far as Norway and Sweden. That the waters of the ocean should have been affected in situations, far removed from the centre of the concussion, will not, perhaps, excite surprise, when it is known that an immense wave was produced at Oporto, and that ships at sea a considerable distance from the coast also felt the concussion. But, independent of the sudden flow and ebb of the waters on the sea-coast in England, Holland, Norway, etc., the same agitation was observed in *inland collections of water*, as ponds, lakes, etc. Thus, at the same time as the concussion in Portugal, and the agitation of the sea in that and other countries, the water in ponds in various parts of England, and the canals and dikes in Holland, was observed to be agitated and to have its level altered. At Whiterock, in Glamorganshire, the water suddenly rose in the river, floated two large vessels, the least of them above 200 tons; broke their moorings; and nearly upset them. This effect, says the writer of the account, *was not felt in any other part of the river;* so that it (the water) seemed to have gushed out at that very place. This sudden movement in the river, in ponds and canals, could, we may conclude, only arise from the discharge of water and other matters, from the springs which rise up at the bottom of these inland collections of water. At least, this would seem to be the only fair inference, when we find that no concussion was felt on the dry land for hundreds of leagues from the spot where the phenomenon occurred. This conclusion is strengthened by the fact, that at Toplitz in Bohemia, and many other places, the hot springs had their contents rendered turbid; at the same time that large quantities of water rushed out with great violence—on the day that the concussion and the other phenomena occurred. We may, also, further infer, that this sudden discharge of water from springs, is produced by the escape of gazeous matter through these particular channels. That such is the case with those springs, which are affected in the immediate neighbourhood of the concussion, we have abundant evidence to show; while we have a right to infer, from analogy, that the same effect is produced from the same cause in other situations. The boiling in the sea observed at particular times and in particular situations, before any concussion has been felt, could be produced in no other way. That the movement in the water of ponds, etc., in places far removed from the centre of the concussion, and in situations, in which no other effect referrible to the same cause has been observed, is also produced by the escape of gazeous matter from the springs beneath, may be inferred from a phenomenon, stated to have taken place at Amsterdam and other places. This was a sudden vibration and movement in the chandeliers and other pendulous articles in the churches and houses, at the moment when the agitation or movement in the waters was observed, although the atmosphere appeared to be perfectly calm. This effect admits of explanation, by supposing that there was a sudden rush of air from some source, and as the water in the canals and dikes (and which, be it remembered, had no communication with the sea, and could not, therefore, be affected by the immense wave produced in the ocean) were similarly affected, we may conclude, that the elastic matter, which gave rise to the phenomenon, was derived from the springs beneath—especially as the effect was too sudden and too great to have been produced by any insensible concussion of the crust of the globe.

If, therefore, various gases are not only generated in subterranean reservoirs, but are also extricated in considerable quantities, into the surrounding atmosphere, to the direct action of some one, or more, of these products on the human frame, we may possibly refer the production of epidemic diseases. That many of these elements are of an injurious nature, we have proof, not only from chemical analysis and investigation; but, also, from the fact, that extensive disease and mortality frequently occur after volcanic eruptions and concussions, among the inhabitants of the surrounding districts. Thus, the consequence of the earthquake in Jamaica, in 1690, was, we are told, a general sickness—3,000 persons of those who survived the effects of the shock being swept away by the pestilence. Again: In the eruptions in Italy in 1329, every species of animals, with multitudes of the feathered creation, perished in great numbers. Seneca also relates, that a vapour, caused by an earthquake in Campania, destroyed 6,000 sheep. As it is only on the supposition of some poisonous element having been extricated into the atmosphere, in these instances, that will enable us to account for such results; to the same cause we must doubtless refer the production of epidemic diseases, if, as we have inferred, they are due to volcanic action. As, however, these diseases are not only observed over extensive tracts, but continue to prevail for a long period, at times when we have no proof of the existence of volcanic action, in those particular situations,—as evinced by the eruption of the volcano or the shock of the earthquake,—it becomes a necessary and important question to ascertain, if the same result is produced at other times by the same means.

Now, independent of the effects before referred to, in situations where an eruption, or an earthquake, is afterwards experienced, or, at times, when these phenomena occur in contiguous situations or neighbouring countries, we have also proof that a vapour arises from the bowels of the earth, or, at the least, is extricated from some source, and diffused in the air at other times, and when the above phenomena are entirely wanting. To the same reservoirs, and the same channels we must, no doubt, look for this evolution of gazeous matter, although we have no proof at the time of the existence of volcanic action in that particular locality. That the dense fogs so frequently experienced, at particular seasons and in particular countries, are produced by exhalations from the earth, few, perhaps, will be inclined to question. But that they are derived from the same reservoirs as those which supply the ducts of volcanos, will, perhaps, be as stoutly denied. That such is the case, however, I am led to infer from the fact, that some of these fogs appear to obey the same laws as all other and well known effects of volcanic action. Thus fogs are frequently confined within very narrow boundaries—not only intersecting a country but even a town; so that while one part has been enveloped in a dense fog, the remainder has been quite free. But, although the boundaries, or limits, of fogs are thus defined, they are nevertheless found to extend over considerable spaces in some particular direction; while, in other instances, different localities have been enveloped in fog at the same moment. In proof of this I may remark, that, when a great fog has prevailed in London, there has frequently been one of equal density in Dublin. I would therefore infer, as a consequence of the foregoing, as well as from the fact, that the cause of the extrication of these vapours cannot, in general, be referred to any peculiarity of soil, that they are derived from subterranean reservoirs.

If this conclusion be correct, and if we also infer that epidemics are produced by the extrication of some deleterious substance, generated in subterranean reservoirs, we can understand, why mists should be so frequently the forerunner, or the accompaniment, of these diseases. This fact has been noted at all epidemic periods; and was remarked, in particular places, during the march of the epidemic cholera; while instances of great fogs, or mists, causing extraordinary darkness, have occurred in every age, and have almost invariably been contemporary with pestilence. Thus the plague of Ægypt in Pharoah's time was attended by darkness: as was that in Rome, A. D. 252 and 746. In the plague which desolated Rome, B. C. 296, there was also a remarkable darkness, under favor of which the Samnites attacked the Roman lines. We also hear of the same phenomenon during the prevalence of the black death of the 14th century; for the greater number of writers speak of the thick, stinking mist, which accompanied the march of this plague:—" A dense and awful fog," says one writer, " was seen in the heavens, rising in the east, and descending upon Italy."*

* *Mansfield Chronicle.*

Again: On the first appearance of cholera at Dantzic, on the 27th of May, there was a very unusual, dense mist, and it became, accordingly, dark long before sunset. It was commonly reported, said Dr. Hamick, by many persons, who were abroad, that the mist had a peculiar, disagreeable smell, and taste, so that those exposed to its influence were forced to wash their mouth with water. A similar mist appeared just before the first appearance of the disease in Rheimfeldt, and again in Dantzic on the 8th June following. I have heard, continues the above writer, this fact of the concurrence of mists with the first appearance of cholera stated by several, and Dr. Barchewitz obtained written statements of it by conscientious and intelligent observers, so important did he deem it.*

Thick mists (of a bluish colour) were observed to precede the diffusion of the memorable murrain described by Dr. Winklan; a malady which broke out in Italy, and spread through Switzerland, Germany, Poland, and Holland, until it at last reached England. Like human pestilences, this murrain travelled onwards slowly and regularly, infesting country after country, and district after district in succession; never appearing in very distant places at the same time, nor continuing its ravages in one spot beyond a certain period. No cattle on the line of its march, as we are informed, escaped; for those that were within doors fell ill at the same time, and in the same manner as those in the open fields. *

---

* *On the Cholera at Dantzic.*

It is a remarkable circumstance, and confirmative of the opinion now given, as to the cause of these mists, that they not only extended over the same countries as the disease; but they also had, like it, a regular rate of travelling — being about 14 miles an hour. In addition to this, it appears, from the instances of the same kind given by Webster, that the phenomenon is not only most frequently observed during pestilential periods; but, also, at those epochs, when eruptions and earthquakes are most common—a fact which tends to show more directly than any thing else that the matter is derived from volcanic reservoirs.

But then it may be argued, that these mists are only accidental, and not invariable accompaniments of epidemic diseases; and that, as such, they cannot be the cause of their production. This argument is probably a just one; for the poisonous element may, if contained in the air, be sensible neither to the sight nor the smell, as is certainly the case with the poison termed malaria. In fact, I would myself infer that the mists and fogs, which accompany the march of epidemics, are merely proofs, that a great evolution of gazeous matter takes place at such periods from the interior of the globe; and that, therefore, it is probable a poisonous ele-

---

* *Dr. Adam Neale, on Animate Contagion.*

ment of some kind may be extricated at the same time and from the same sources. It is, also, to be remembered, that these mists are principally observed in cold and damp climates; for in warm regions phenomena of a different kind have been experienced. Thus, although fogs and mists have been sufficiently common in Europe, both during the march of the black death and the epidemic cholera, the only evidence of the presence of vapour in the atmosphere in the East and in Asia, has been a redness of the sun's disk, and a peculiar kind of haze in the upper regions, with obscurity of the sun's rays.

Independent of the above, there are some other proofs of the presence of a deleterious or foreign matter in the atmosphere at all epidemic periods. In the destructive plague which raged in the year 262, and when 5,000 persons died daily in Rome, Eusebius states that the air was so highly corrupt as to form on objects a mould, or coat, like the turbid dew from dead bodies. The fatal angina maligna among cattle, in 1632, was attended with a blue mist, or dew, on the herbage or pastures: and Webster remarks, that the air of New York, in 1579, produced astonishing effects in the generation of mould; and the rapidity in the process of putrefaction was almost incredible—a result very common in malarious districts.

Impressions of curious figures on garments have also been observed during pestilential periods, while they have also been visible on the doors of houses, and other articles. This was particularly the case during the plague of 542 and 600. Similar figures appeared in the pestilence of 746, and which the writers of that period, who state that they were looked upon with superstitious horror, call *cruciculæ*, or little crosses. That the cause was the extrication of some vapour from the bowels of the earth may be inferred not only from the circumstance, that it is impossible to account for the effect in any other way; but from the fact, that similar impressions have been observed after volcanic eruptions—as was the case after that of Vesuvius in 1660; and referred to by Boyle.

That the poison productive of these diseases is present in the atmosphere, we are bound to conclude, not only from the arguments made use of in this and the first part of the present treatise, but, also, from the fact, that at such periods the whole class of animated beings are similarly, if not equally, subjected to the invisible agency of this universal cause. Thus, independent of man, cattle of all kinds, as well as the numerous species of the feathered race, are found to be more or less affected at the same time; and in a manner, and to an extent, which can leave no doubt on the mind of any candid inquirer, that the affection in the lower animals is due to the same cause as that, which produces disease and death in the upper classes or man.

During the prevalence of the epidemic cholera an unusual mortality occurred amongst the black cattle, sheep, dogs, and other domestic animals in India. The symptoms were like the cholera, and were best removed by the same means as in the human subject. A similar circumstance was observed in Russia, and Prussia, according to Dr. Joenichen. But it was during the black death of the 14th century, that the affection in the lower animals was most apparent; for the disease was soon accompanied by a fatal murrain. In England 5,000 sheep died in one pasture alone; and, as had been observed in Africa, the birds and beasts of prey are said not to have touched them. Diemerbroeck also informs us, that he was frequently an eye witness to the fact, that whenever small birds, confined in cages, died, the inhabitants of the house were invariably attacked in a few days with the plague.*

But, although domestic and other birds are attacked with disease and die, during epidemic periods, fowls of the air and birds of prey desert the place, as if conscious of the alteration in the atmosphere. Of this fact there can be no doubt, for it has been frequently observed, during the occurrence of plague, from the time of Livy to the present day.

---

* We find the same circumstance referred to by Homer; who says,

"On mules and dogs the infection first began:
And last the vengeful arrows fixed in Man!"

That the cause of pestilence exists in the atmosphere, would also appear from the fact, that at all epidemic periods vegetable life is affected, as well as animal. Hence, as Webster has remarked, pestilence, murrain of beasts, and famine occur at the same time. We find this to have been the case in the earliest record we have of pestilence; for it is said in scripture, that the plague of blotches and blains, the murrain of beasts, and the blight producing famine in corn, all visited Ægypt in close succession. The same circumstance was observed in the black death of the 14th century, as we have before shown, while considering the atmospherical changes and vicissitudes which occurred at this period: for although there was an abundance in the granaries at the commencement of the plague, failures in the crops became so general, subsequently, that children died of want in their mothers arms.

That the famine in these cases is not the cause of the pestilence is certain, from the fact, that plagues have frequently commenced in the midst of the greatest plenty; while famine, when it occurs at epidemic periods, follows the disease in the generality of cases. This shows, that vegetables are able to resist the malign influence, which produces disease, for a longer period than animals. That the destruction of vegetable life is produced by the same cause as that which gives rise to disease and death among animals and the human species, we may infer from the fact, that the same peculiarities are observed in the one case as in the other. Thus blights, like epidemic diseases, are only observed along *particular lines* of the earth's surface; for so defined is their boundary, that they will not only intersect a field, but they will even attack one side of a tree, and leave the opposite untouched. That the cause, productive of these effects, cannot exist *generally* in the atmosphere is clear from the limitation of its operation to such narrow boundaries. It is only on the supposition, that some poisonous element is extricated from the soil along the lines taken by the blights themselves, and which becomes innocuous at a certain distance from dilution in the surrounding atmosphere, that will enable us to account for the effects observed. But the poison, although extricated on the surface, cannot be produced from any peculiarity of soil, as this is found to have no influence on their direction, or limitation; for blights are frequently seen to extend along a line only of some particular district, the geological and other features of which are exactly the same.

Again: These diseases of vegetables, like those which attack animals, frequently spring up in some particular district, where, previously, they were unknown; continue to prevail for certain definite periods; and then subside. Thus it has been stated by some writers, that wheat had not been known to mildew in France until the year 1550—an epidemic period, and that in which the black death prevailed in Europe. Webster also informs us, that it has been impossible to raise wheat in Massachussets since 1664, on account of the mildew—although it was successfully produced by the first settlers in that country. As these affections of vegetables are only observed at particular epochs, although the soil, and all other external circumstances remain the same at other periods, to a cause existing beneath the surface we can alone look for the generation of the poison productive of these effects among vegetables, the same as animals. This cause, if the deductions before drawn are correct, must be that usually designated volcanic action, as we know of no other process which could give rise to the same effects.

If the foregoing arguments therefore have any weight, we are bound to conclude, that epidemic diseases are not only produced by volcanic action; but, also, that the immediate cause of their production is the generation of a poisonous substance in subterranean reservoirs, and its extrication on the surface by means of those channels, which exist to a greater, or less extent, in all situations.

This inference is apparently confirmed by the remarkable circumstance, that at all pestilential periods the fish in the sea, and in rivers and ponds, not only die in large quantities, but, when the opportunity for acquiring the information has been afforded, they have been found to be affected in a similar manner, or, with a similar disease to that which was prevailing among the human species. In 222 a pestilence, which destroyed 100,000 persons, raged in Scotland: at the same time, a great mortality of fish was noticed, and multitudes were washed ashore on the coasts of Great Britain. "In 1240," says Webster, "mortal diseases prevailed, and authors relate that the fish on the English coast had a battle in which 11 whales, and a multitude of other fish were slain, and cast ashore. The cause, to which this phenomenon was ascribed, although ludicrous enough, is important; for it strengthens modern observation, that, when pestilential diseases prevail on the surface of the earth, fish often perish beneath the waters."

So, also, when the black death was prevailing, there was, in addition to a murrain amongst the cattle, a pestilence, which carried off immense quantities of fish, whose bodies were found on the seashore covered with blotches.

The same phenomenon was observed in many places during the prevalence of the epidemic cholera, but principally in inland collections of water. Thus, multitudes of dead fish were found at this time in the ponds in India, Russia, Prussia, and other countries. At Havre, the citadel of which is surrounded with a deep ditch, that always contains a large quantity of fish, a remarkable circumstance, as we are told by Dr. Licardi, took place in the month of August, 1832, the year of the prevalence of the epidemic cholera in France. It was remarked by many persons, says this writer, that the water here suddenly changed its colour and became muddy; while *bubbles of gas* rose to the surface, and caused a considerable ebullition. At the same time the fish, and particularly the eels, which are almost constantly at the bottom, were observed to spring above the surface of the water with a convulsive movement, and then to drop again, languid and heavy, into that fluid which was found to act upon them as a poison, after having been the source of their life, and nourishment; for in a few hours the surface of the water was covered with dead fish. The inhabitants of the neighbouring sea were not exempt from the operation of the same cause, for the sea-shore was likewise covered with an immense quantity of dead fish.* *A few days after* the cholera broke out in the town, and raged with considerable violence.

Now it is precisely in such situations that, as I have attempted to show, so large an evolution of gazeous matter takes place from volcanic foci, at the time of the eruption of the volcano, and the shock of the earthquake. That some of these elements are of an injurious nature we have proof not only from the circumstances before mentioned, but, also, from the fact, that during the time of volcanic eruptions the fish in the neighbouring waters are frequently destroyed in large quantities; even when the inhabitants of the atmosphere above entirely escape. Thus in the eruption which took place in the island of Lancerote, in 1730, dead fish floated on the waters in indescribable numbers, or were thrown dying on the shore. In June 1731, also, during a renewal of the eruptions, all the banks and shores in the western parts of the island were covered with dying fish of different species; some of which had never before been seen.

---

* *"Sur la coincidence des Epidemies humaines avec celles des poissons."*

This simultaneous affection therefore, of the finny race, with the beings that live and breathe in the atmosphere surrounding the globe, affords a strong corroboration to the conclusion before drawn, viz., that the agent productive of these effects is derived from volcanic foci, and that it escapes from the interior to the exterior by means of those streams which rise up as freely beneath the waters of the ocean, as on the dry land. That some deleterious matter is diffused in the water of springs, at epidemic periods, has been a popular opinion during all ages, although the cause of its presence there has been generally referred not to natural, but human means—as was stated in the first part of this work. In addition to the reasons then assigned for this opinion, I may mention, that during the time of the plague in Vienna, as we find from Sorbait, a fountain in the suburbs, which had always been esteemed for the salubrity of its waters, exhaled a stench to which the greater mortality in that situation than others, was attributed. Webster, also, states, that during the pestilential period of 1795, the water in the wells at New Haven appeared to be in a bad state, as evinced from the number of animalculæ which it contained.

If, therefore, we find, that poisonous elements are generated in subterranean reservoirs, and that they become diffused in the surrounding atmosphere; and if, also, it be allowed, as we have before inferred, that volcanic action takes place along particular lines of the earth's surface, we have only to prove that this action is in existence at the time, in order to account for the origin and march of epidemic diseases. This it has been attempted to show is the case, by a reference to the phenomena witnessed during the prevalence of such maladies; for volcanic effects would seem to be the invariable accompaniments of epidemic diseases. As this, therefore, was the question to be solved, we have, it is hoped, afforded a probable, if not a satisfactory, solution of a problem hitherto considered alike difficult and impracticable.

CONCLUDING REMARKS.

If the foregoing theory be a correct one, we must necessarily arrive at the conclusion that it is *places*, and *not* persons which are infected at epidemic periods. Such a conclusion will not only account for all the facts, that have given origin to the doctrine of contagion; but, it will also explain those anomalies, which do not receive elucidation from this theory,—as will be apparent by a reference to the observations, that have been before made on this subject. To enter fully into this important question would occupy so much time and space, that I must content myself, at the present, with referring those, who are anxious for further information, to works expressly devoted to the subject; by which it will be seen, that there are so many circumstances, which can never be explained by this doctrine, that a great number of talented writers have long ago come to the conclusion, that even the plague itself cannot be propagated by human means, —although they were, at the same time, unable to account for its origin, or propagation, in any other way. Some have supposed, that, like so many diseases, it is a product of malaria; for the laws, which regulate the diffusion of the poisonous matter productive of plague, appear to be so similar to those, which govern the extrication and diffusion in the atmosphere of the poison termed malaria, that we might suppose the same element was in operation in the one case, as well as in the other. So many arguments, however, have been advanced against the justness of this conclusion, that no attempt has of late been made to trace the analogy farther; so that even those, who disbelieve the power of contagion, hesitate to combat the doctrine from an inability to show, in what other way the disease may be produced.

But all doubt and difficulty on the subject ceases, if, instead of inferring, that a poison is given out from the bodies of the sick, or generated on the surface of the earth, we conclude, that a poisonous matter is extricated from subterranean reservoirs, and that it becomes innocuous where largely diluted in the atmosphere; for it is clear, that, in such a case, the effects of the poison can only be observed in particular spots of *limited extent*, or along particular lines of the earth's surface; and then *only* in situations where men, or animals, are congregated together. It would also appear, if the arguments before used have any weight, that the extrication of gazeous and other matter along the lines, which mark the operation of volcanic agency, sometimes takes place slowly and progressively. If so, we can account for the spread of epidemic diseases, and their extension from country to country, independent of contagion, or human infection. As, also, the existence of the poison can only be known by its effects on man, we can understand, why it should be observed more particularly in towns, at the mouths of rivers, and along high roads; for it is precisely in such situations that population exists to the greatest extent; and it is there, consequently, where such diseases must prevail to a greater degree than in other situations.

But the matter does not rest here, for independent of the question, as to the origin of epidemic diseases, and the solution of a problem so important and interesting to the world at large, as that of the existence or non-existence of contagion, it would be easy to show, if space could be afforded for the purpose, that endemic diseases are produced by the same cause as epidemic. In fact, endemics are, it would seem, either the remains of epidemics, or, more properly speaking, of the cause which produces the latter; or, else, epidemics are only aggravated forms of common and local complaints—with this difference, that in the one case they are confined to particular spots, and in the other prevail over extensive tracts of the earth's surface. Thus it was remarked, that fevers preceded the black death of the 14th century, being mild in their character at first, and then increasing in intensity until they terminated in the severest form, or plague itself. The same phenomenon, only in an inverse order, was observed after the subsidence of the plague, and at each successive eruption. So, also, the epidemic cholera was preceded by common diarrhœa, or dysentery; while it was followed by the same complaints or intermittents — being observed in situations where they were uncommon before; or, else, to a very unusual extent in spots where such affections are endemic.

That endemic diseases are produced from the same cause as epidemics, and that this cause is the process to which the term volcanic action has been applied, I would argue from two circumstances; the first of which is, that the whole of these maladies are occasionally, or have been at some former period, epidemic; and the other, that they prevail to the greatest extent, and in the greatest intensity in those regions where volcanic action is known to exist in the greatest intensity. Thus the plague, or, as it was then called, the black death, after spreading over the greater portion of the globe in the 14th century, continued to return epidemically, at particular periods, and uncertain intervals, until the middle of the 17th century, when it subsided entirely in Europe, and is only now witnessed in Egypt and Turkey. It is probable that the same circumstance will occur with the epidemic cholera; for, although this disease has not returned epidemically in other parts of the world, since the first years of its prevalence, it is still witnessed in India, more or less, every year.

In the second place, certain of those diseases, generally acknowledged to be produced by malaria, prevail almost exclusively in Italy, the throne, as it has been termed, of this invisible agent, as it is of volcanic effects. The plague, also, as will be particularly apparent, is the endemic of a region which is one grand theatre of volcanic action—the boundaries and extent of which were described in the first part of the present work. Again: The yellow fever is only observed (except at particular periods when it becomes epidemic and spreads beyond) in the West Indies, and contiguous countries—a well known volcanic region, being, in fact, the latitudes where those grand phenomena of nature occur which I have attempted to trace, to the operation of volcanic action. So, also, as regards that disease, which is the endemic of the East, as fever is of the West Indies, viz., dysentery. This we shall find prevails chiefly in the neighbourhood of that remarkable volcanic chain, which extends from Barren Island through Java, Sumatra, etc., and where the severest and most acute cases of this disease are to be met with.

That such a process as volcanic action (which exists to a greater or less extent over the whole globe, and continues for indefinite ages in one particular spot or region) should give rise to the whole of these effects, need not excite surprise; for if it has been allowed that so transitory and uncertain a process as that of animal and vegetable decomposition could give origin to a substance, to which, as has hitherto been supposed, two-thirds, or more, of the diseases which affect the human race are to be ascribed, we cannot fail to infer that the same, or greater effects, may be readily produced by the above cause. That this cause, or that, which gives origin to the severer epidemic, or pestilence, is productive of a variety of effects, may also be inferred from the fact, that at all epidemic periods, the influenza invariably precedes and follows the more severe disease, passing over the same countries, and the selfsame track, as the pestilence itself—with this only difference, that its rate of progress is much greater than the latter, the influenza having been known to traverse, in a few weeks, the same track that the pestilence, which preceded it, took some months, or years, to pass over. This was well observed in the influenza, which succeeded the epidemic cholera, and which travelled from the north of Europe to England in a few weeks, attacking all the towns and places situated on the line, or track, which the cholera had previously pursued.

It is also a fact, that other diseases, the form of which is entirely different to that of the pestilence itself, are more prevalent at epidemic periods than at other times. This is particularly true with respect to the measles, small pox, scarlatina, angina maligna, and the different forms of fever—the truth of which has been satisfactorily shown by Webster in a series of statistical tables. In other instances, again, we shall observe a variety of diseases occurring, at the same time, along a particular line of the earth's surface; for while fevers are prevailing at one spot, colds and influenza, or some other form of complaint, are attacking the inhabitants in a different region or country. This has been found to occur so frequently, at the same moment, and in the same portions of the globe, that we can hardly fail to infer the same cause is productive of all the effects witnessed in these particular instances. Webster states, that he has not been able to find an instance in which the plague has made great ravages in the East, except when the measles, scarlatina, influenza, angina, or pestilential fevers have prevailed on the continent of America—while, in the majority of cases, the violence of the latter diseases has kept pace with the former.

That these effects are produced from subterranean causes may be inferred from the circumstance, that they have been witnessed along a well known volcanic line; for concussions and other signs of volcanic action have frequently occurred in the same spots and in the same direction. It is also remarkable, and confirms the hypothesis now advanced, that atmospherical phenomena, characterized by the same order and progressiveness, have frequently been observed along the same line, at particular periods. Numerous examples of this kind have been given by Webster, for while great droughts in America have preceded eruptions of Ætna and Vesuvius; they have been followed by heavy rains and inundations; or, great cold, with falls of snow, at unusual times of the year.

With these few observations I must now conclude, not only because it would be impossible to enter fully into the question in the present work, but, also, because it is my intention to return to the subject on another occasion; when I hope to be able to show, that endemic diseases are produced by the same cause as epidemic; and, also, that the invisible, and almost universal, agent malaria is generated in subterranean reservoirs, instead of being, as we have hitherto supposed, a product of animal and vegetable decomposition.

APPENDIX.

Since the publication of my work on the Treatment of the Cholera, the following report, which I was unable to obtain at the time, has been forwarded to me. As the document is a valuable one, I have thought fit to add it, in the present place, from a feeling, that we ought to be prepared for returns of the disease, and from a desire to convince others of what I myself firmly believe,—that Carbonic Acid Gas is a certain and safe remedy for the Epidemic Cholera :—

"*REPORT of the Commission appointed by the Royal Academy of Medicine and Surgery, in Barcelona, agreeably to the order of the Supreme Board of Medicine and Surgery, in Spain, that it should make known what plan of Treatment had produced the best effects in the Epidemic Cholera, in those Towns situated in the districts under the jurisdiction of the Academy, and which had been attacked by the disease.*

After a few introductory remarks, respecting the nature of the duties the commissioners had to perform and their obligations, together with the contradictory accounts that had been given respecting various remedies, and the failure of those that had been most vaunted, the report thus proceeds:—" After the first cases which presented themselves, the following plans of treatment were adopted: general and local bleedings; abstinence from all solids—the patient's diet being reduced to only toast and water, or rice-water: the external and internal application of refrigerants; sudorifics; antispasmodics, and opiates; hot and vapour baths; the powders of vivorera (of Murcia) so strongly recommended: water acidulated with sulphuric acid, named, *par excellence,* the anti-cholera mixture; derivatives and blisters, varied in a thousand ways; the moxa; cupping; the sulphate of quinine, in large and gradually increased doses, in powder and dissolved in water by means of dilute sulphuric acid; frictions of various kinds, and other agents which increase the heat of the body; camphor; musk; ipecacuanha; oil of olives; the sulphate of copper and iron; the oxide of bismuth; the aristoloquia, etc. But, what cause for lamentation! nearly all the patients that had the disease at all severally perished—notwithstanding that, in the application of the above means, the requisite attention was paid to the circumstances in which the patients were found, in order to determine the proper occasion for their employment, and which is necessary in the administration of every remedy.

"This truth, lamentable as it is, the commissioners have had the sorrow to experience; but they hope to lessen its bitterness, by submitting to the judgment of the academy a plan of treatment which, according to their ideas, in addition to being the most appropriate, *offers great simplicity,* and is the same, with a slight difference, which many practitioners have adopted with *the most happy result,* according to the official communications made to this academy. [After drawing a distinction between the bilious diarrhœas which prevailed at the same time, and which were found to yield to the ordinary plans of treatment, the commissioners add, that the indication was entirely changed when the excretions were composed of the true choleric fluid; and when, in addition to the rice-water evacuations, similar to those of dropsical patients, there is an alteration of the physiognomy, and a certain morbid condition of the surface of the body (blueness), which gives that appearance and similarity common to all in this state, in spite of the number or diminution of the other symptoms]. *When this is* *the case* (*i. e.*, when collaps has supervened), *the employment of carbonic acid gas produces wonderful effects*—administered according to the method of Dr. John Parkin (an honorary fellow of this academy), either in combination with water, or, as you may say, by forming the gazeous acidulated waters, obtained by the decomposition of the bi-carbonates of potash or soda, by means of the citric or tartaric acids. As auxiliaries, blisters may be employed, and enemas of starch or linseed, and, for the cramps, frictions with common oil, either with or without laudanum ; or, what is better, with asafœtida and camphor dissolved in vinegar. This treatment should be continued even in the stage of collapse (cholera asphyxia), on account of its being *the most efficacious and direct of all the plans that have been tried*—and it is certain that, if it is used at the commencement, and the patients do not neglect to call the medical attendant, after the disease has once manifested itself, *there will be few who come to this state of atrophy and wretchedness.*" The commissioners then, after a few more cursory remarks on some unimportant subjects, as the allowance of cold water, the treatment of the febrile stage, etc., etc., conclude their report in these words:—"The commission, in giving this opinion, has endeavoured, *without any other object than the truth and the future progress of science*, to reject every doubtful and fanciful theory, which leads only to error, and which might be perpetuated, if, through timidity and ill-judged consideration, it had remained silent. The commission has made it a duty to conform entirely to this fundamental axiom, that facts, well attested and separated from all theory, are, in the treatment of diseases, the only durable acquisitions."

In a note which I received, at the same time, from Dr. Sauch, the then medical secretary to the academy, the writer says, in answer to some inquiries of mine on a particular point, "it is impossible now to ascertain the proportion of cases of collapse, on account of the little regularity observed by the different writers in their communications to the academy—but it is," he adds, "clearly deducible from the above report that there were plenty, since, at the commencement of the epidemic, nearly all the patients attacked with cholera died. I can assure you," continues this gentleman, "that, by the help of carbonic acid gas, I obtained cures, and no few, more than 30 of cases of *confirmed collapse.* In fact, from what I then saw in my private practice, somewhat extensive, I can affirm that the treatment of the cholera with carbonic acid is truly scientific; the gas in this case is the *real antidote to the disease,* and, consequently, the supporter of life; up to the present time it is the *only therapeutic agent* which, taken scientifically, is capable of destroying the organic lesion, by directly changing the morbific action which produces the cholera. Such admirable results we may in vain expect to obtain from any of the other methods which have been adopted, the whole of them being, more or less, unsuitable or useless."

"The document which accompanies this," adds Dr. Sauch "was remitted in the name of the academy to the proper authorities, who approved of the report in all its parts, and of the opinions given by the commission, specially named by them, and of which I was secretary."

Before closing this paper, I would wish to observe, that a translation of my work on the Cholera was made into Italian, and published about the period of the outbreak of the cholera in that country. As it passed through two editions in the short space of three months, it is to be inferred, that the treatment there recommended was not only adopted to a considerable extent, but that it met with some success—a fact I have had confirmed by private individuals who were on the spot at the time. But the only direct evidence, I have obtained on the subject, is from the letter of an English gentleman, resident in Sicily, to his brother in England, whom he thus addresses :—" As for anything like a fair trial of Mr. Parkin's system, there was no time for anything of the sort. I got his book into circulation as much as I could, and *I know* that many in Palermo have tried it with success; nor have I heard of *a single instance* where any one has taken his medicine as a preventive that has been attacked with the disease. I am also acquainted with a nobleman who, having studied medicine as an amateur, had been induced to read Mr. Parkin's work, and who arrested the progress of the disease in 12 individuals by the administration of the same remedy."

DRURY, PRINTER,
17, Bridgewater Square, Barbican, London.

Works by the same Author.

AN INQUIRY INTO
THE
CAUSE, NATURE, AND TREATMENT OF GOUT;

With the view of pointing out a safe and effectual remedy for the cure and eradication of this painful and intractable disease.

Demy 8*vo., cloth boards. Price* 8*s.*

HATCHARD & SON, No. 187, PICCADILLY.

ON THE
ANTIDOTAL TREATMENT
OF
THE EPIDEMIC CHOLERA.

Demy 8*vo., cloth boards. Price* 5*s.*

ON THE
EFFICACY OF CARBONIC ACID GAS
IN THE
DISEASES OF TROPICAL CLIMATES:

Or, those produced by the poison termed Malaria.

Demy 8*vo., cloth boards. Price* 5*s.*

G. HIGHLEY, No. 32, FLEET STREET.